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From Communities Of Practice To Classroom Communities Of Inquiry: Engaging Students In Meaning Construction

Scott Gregory Johnson
University of South Carolina

From Communities of Practice to Classroom Communities of Inquiry: Engaging Students in Meaning Construction

by

Scott Gregory Johnson

Bachelor of Arts
Fresno Pacific College, 1996

Master of Education
Fresno Pacific University, 2003

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Accepted by:

Heidi Mills, Major Professor

Tasha Tropp Laman, Committee Member

Lucy Spence, Committee Member

Eliza Allen, Committee Member

Lacy Ford, Senior Vice Provost and Dean of Graduate Studies

DEDICATION

This paper is dedicated to my biggest supporter and encourager, my wife, Malisa Johnson. Without her I would have never completed this paper.

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In a recent television interview, Pharrell Williams, a Grammy Award-winning musician and producer, was asked to share his story of growing up. In that interview, Pharrell Williams stated that his story of growing up was the average story – a story which was filled with special people. When the interviewer remarked that he was giving credit to other people, Pharrell Williams shared, “What am I without them . . . take all my band teachers out of this. Where am I? I’m back in Virginia doing something completely different” (Pharrell Williams, 2014). After watching this interview, I realized our stories were similar. Pharrell Williams and I understand that our journey in life is influenced by the people around us. Instead of ignoring the obvious, we embrace and honor those who helped get us to this particular point in our lives.

Debbie Manning and Jean Fennacy were my first mentors, and somehow managed to see through the mess that was me. Debbie and Jean, you have a gift for noticing the potential in everyone and you believed me into being. I will always be thankful for your love, support, and guidance while on this journey. There is no way I could have arrived at this point in my career without you and for that, I am eternally grateful.

Brian Helmuth, professor at Northeastern University and a former parent at the Center for Inquiry, changed my life professionally when he invited me to learn alongside him in Oregon. The experience provided an opportunity to notice learning in a whole new context. This, in turn, changed my classroom for the better.

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I would like to acknowledge the support of my family. Dad and Mary, and my mom, thanks for watching the kids. Dave and Lisa, thanks for your patience during this process. I know having your daughter and grandchildren so far away has not been easy. I want to extend my thanks to my extended family at the Center for Inquiry. I could not have accomplished this research without your support. You provided feedback and pushed my thinking professionally. You were understanding when I became absent minded and deep in thought; and you picked up my slack when times were busy.

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stood by during every frustrating moment, and celebrated each triumph. I love to do life with you!

ABSTRACT

Gordon Wells (2001) stated that policy makers and educational planners believe there is a crisis in public education. These individuals talk about improving the "delivery of a standardized education" (p. 172) and creating nation-wide assessments that ensure particular outcomes. On the other hand, Wells (2001) discussed academic researchers who are interested in students achieving "depth of understanding" by emphasizing the importance of *inquiry*, *construction of knowledge*, and *collaboration*. Unfortunately, Wells (2001) also believed that the daily practice of classroom teachers lies somewhere between these two perspectives, meaning their teaching practices may not always align with their teaching philosophy. This research is my admittance that my practices did not always live up to my beliefs. By participating in an apprenticeship experience, working alongside scientists collecting climate change data, I recognized the importance of teaching in ways that reflect my beliefs. This study demonstrates when teachers put the assumptions that underlie their beliefs to the test (Harste, Woodward, & Burke, 1984), through belief maintenance (Schreiber & Moss, 2002), they deliberately position themselves to grow new beliefs and practices.

The purpose of this study was to identify features of an apprenticeship model that promoted authentic learning while working along-side scientists investigating the intertidal zone of the Oregon Coast in order to approximate those conditions when creating curriculum in my fourth grade classroom. As a teacher researcher (Cochran-Smith & Lytle, 1993; Herr & Anderson, 2005; Hubbard & Power, 2012), I employed

qualitative research methods (Marshall & Rossman, 2006) to study how we constructed knowledge in Oregon to apprentice my students through a unit of study on climate change.

TABLE OF CONTENTS

Dedication iii

Acknowledgements iv

Abstract vii

List of Tables xii

List of Figures xiii

Chapter 1: An Experience of a Lifetime: Teacher as Apprentice 1

    My Tension Led to Further Inquiry 5

    Statement of the Problem 6

    Research Purpose 12

    Type of Study and Research Questions 14

    Overview of Theoretical Framework 15

    Significance of the Study 21

Chapter 2: Theoretical Framework and Review of Pertinent Literature 23

    Sociocultural Framework 24

    Inquiry as a Philosophical Stance 35

    Classroom Community of Inquiry 45

    Conclusion 51

Chapter 3: Methodology 52

    Phase One: Oregon Context 54

    Phase Two: Classroom Context 68

Across Phases......79

Chapter 4: Learning Through an Apprenticeship Model in the World and in the Classroom......86

Features of the Apprenticeship Experience in Oregon......87

Oregon Apprenticeship Experience to Communities of Practice......117

Approximating a Community of Practice During a Unit of Study on Climate Change......118

Chapter 5: Knowledge Construction in Oregon and in My Classroom......149

Knowledge Construction Across Contexts......152

Synthesizing Knowledge Construction in Oregon and the Classroom......196

Chapter 6: Implications and Conclusions......199

Purpose of the Study......199

Summary of Procedures......200

Summary of the Findings......200

Implications for Teachers: Growing New Beliefs and Practices......202

Theorizing From Practice: Implications for Teachers and Practice......206

Implications for Further Research......218

Conclusion......221

References......223

Appendix A: Teacher Consent Form......240

Appendix B: Student Consent Form......241

Appendix C: Ways Knowledge was Constructed......242

Appendix D: Unit of Study on Climate Change......245

Appendix E: Transcript of Emily's *I Think I Know…* Folder......255

Appendix F: Transcription of Exploratory Conversation with Allana, Alexi, Mary, and Teacher....256

Appendix G: Hannah's Statement of Beliefs Paper....261

Appendix H: Beth's Statement of Beliefs Paper....262

Appendix I: Alex's Statement of Beliefs Paper....263

Appendix J: Transcript of Alex's *I Think I Know*…Folder....264

Appendix K: Transcript of Conversation Between Jeena, Alexi, and Teacher....265

Appendix L: List of Citizen Science Projects....267

Appendix M: Citizen Science Schedule....268

LIST OF TABLES

Table 3.1 Comparison of methodological features of Phase One and Phase Two 84

Table 4.1 Comparison of the features of the apprenticeship experience in Oregon and classroom..147

Table 5.1 Ways knowledge was constructed in Oregon and the classroom 197

Table C.1 Ways Knowledge was Constructed 242

Table E.1 Transcript of Emily's *I Think I Know*...Folder 255

Table J.1 Transcript of Alex's *I Think I Know*... Folder 264

LIST OF FIGURES

Figure 1.1 The intertidal zone is the area of seashore covered at high tide and uncovered at low tide 1

Figure 1.2 Teachers measuring the arms of a pisaster and recording the measurements. 3

Figure 1.3. Data logger collects water temperature information 4

Figure 1.4 Motorized device, or gigapan, creates panorama of intertidal zone. 4

Figure 2.1 Theoretical framework 23

Figure 3.1 Beach is divided into two areas 56

Figure 3.2 Organisms found in the low intertidal zone 57

Figure 3.3 Photo documenting student diagram 73

Figure 3.4 Photo documenting classroom discussion 74

Figure 4.1 All tasks in Oregon were structured as community activities 88

Figure 4.2 Students collaboratively worked on a presentation 90

Figure 4.3 Teachers and scientists positioned themselves as learners 91

Figure 4.4 Seven-legged pisaster nudged further questioning 92

Figure 4.5 Student created diagram of global warming 95

Figure 4.6 Mackenzie demonstrated how to dissect a mussel 96

Figure 4.7 Small caliper used to measure the size of mussels 99

Figure 4.8 Tim and Susan collected information while Susanne recorded the data 99

Figure 4.9 Data was collected, coded, and organized 100

Figure 4.10 Data loggers were plotted on a map 101

Figure 4.11 Students' definitions of non-fiction 103

Figure 4.12 Ally's knowing-in-action allowed her to make adjustments to changing conditions 105

Figure 4.13 Mackenzie demonstrated while Amanda, Tammy, and Chris observed and pitched in 109

Figure 4.14 Emily inputted data from the rain gauge......110

Figure 4.15 USA-NPN plant phenophase datasheet 113

Figure 4.16 CFI teaches independently collected data......115

Figure 4.17 Students independently recorded phenophase data......116

Figure 4.18 Students developed a class-wide definition of climate change......121

Figure 4.19 Working definition of climate change 123

Figure 4.20 Reflecting through *I Think I Know*... folder 123

Figure 4.21 Emily documented her thinking by reflecting on her prior knowledge of climate change......124

Figure 4.22 Emily's initial understanding of climate change as written in her *I Think I Know...* folder......125

Figure 4.23 Emily's *I Think I Know*...folder reflected her thinking as it became more sophisticated over time 125

Figure 4.24 Marissa shared her thinking......126

Figure 4.25 Alexi and Mary transacted with their diagrams......135

Figure 4.26 Classroom community created organizer of our understanding of climate change 136

Figure 4.27 Demonstrating to Brandon how to use the gigapan......138

Figure 4.28 Emily and Katie's diagram of climate change......142

Figure 5.1 Classroom community of inquiry 150

Figure 5.2 Data was collected and analyzed 153

Figure 5.3 Students, as a group, found information, reflected on the evidence, and came to their own conclusions 154

Figure 5.4 Alex recorded information on greenhouse gases in his science journal 155

Figure 5.5 Alex's diagram of global warming 156

Figure 5.6 Community members engaged in exploratory talk 159

Figure 5.7 Talk was used to construct knowledge of diagrams 166

Figure 5.8 The way data was expressed was translated between sign systems....170

Figure 5.9 Students used a variety of signs and symbols to represent knowledge meaningful to them 172

Figure 5.10 Hannah and Marissa's diagram....173

Figure 5.11 Beth, Maria, and Mary's diagram 173

Figure 5.12 Students constructed ocean landforms using Legos 174

Figure 5.13 Dr. Helmuth helped Tammy use the laser level....175

Figure 5.14 Metaphor was embedded within Hannah's diagram....179

Figure 5.15 Dr. Helmuth demonstrated how to use the gigapan 181

Figure 5.16 *I Think I Know…*folders documented students' prior knowledge 186

Figure 5.17 Alex's *I Think I Know…*folder....187

Figure 5.18 Student created diagrams of global warming....188

Figure 5.19 Jeena and Alexi reflected on their diagram as they used talk to demonstrate their understanding 189

Figure 5.20 Authenticity of our work provided purpose 191

Figure 5.21 The use of iPad minis made citizen science projects user friendly....195

Figure 6.1 Inquiry as a collaborative process of knowledge construction 207

Figure 6.2 Arduinos allowed students to inquire about open-source electronics and computer programming 213

Figure 6.3 Student created laptop screen projector 213

CHAPTER 1

An Experience of a Lifetime: Teacher as Apprentice

During the summer of 2011, I had the experience of a lifetime. Three teachers from the Center for Inquiry, including myself, had the opportunity to travel to the coast of Oregon to work alongside Dr. Brian Helmuth, a parent at the Center for Inquiry and renowned climate scientist. Dr. Helmuth uses a variety of techniques, which include fieldwork and remote sensing, to investigate how the environment affects the body temperatures of intertidal (seashore covered at high tide and uncovered at low tide) marine life such as mussels and sea stars (see Figure 1.1). By studying fluctuations in body temperature among intertidal marine life, Dr. Helmuth maps out changes in

Figure 1.1. The intertidal zone is the area of seashore covered at high tide and uncovered at low tide.

growth and reproduction rates. He uses this information to inform decision makers on the impact of climate change by providing data that is scientifically accurate. Another goal of his research is outreach towards teachers. Dr. Helmuth invites classroom teachers to engage in research projects to offer first-hand exposure to the scientific process.

In preparation for this trip, teachers from the Center for Inquiry read several articles that would help us become familiar with the language of marine biologists and climate scientists, as well as provide background information on the type of research Dr. Helmuth was conducting. We attended a half-day seminar at the University of South Carolina. Dr. Helmuth outlined the research project and provided details on the equipment and techniques we would use while in the field. Jim Gandy, a meteorologist for a local news station, provided a summary of the difference between weather and climate. Dr. Greg Carbone, University of South Carolina professor and chair of the Geography Department, provided information on the science and the data behind climate change.

As classroom teachers, we were charged with taking measurements and recording data related to the intertidal zone marine life such as mussels and sea stars. We learned we would collect, record, and analyze data and compare new data sets with data collected at the site over the past twelve years. One of our primary responsibilities was to remove pisasters (sea star native to the intertidal zone on the Oregon coast) from the rocky shoreline, measure the length of each arm, and provide a mean arm length for the pisaster (see Figure 1.2). Next we noted the color of the pisaster, its location, and if the pisaster was feeding on its prey.

Figure 1.2. Teachers measuring the arms of a pisaster and recording the measurements.

We also learned about the tools used in Dr. Helmuth's research. He collects data through the deployment of data loggers shaped like mussels often referred to as *robo-mussels* (see Figure 1.3). These data loggers have a built in sensor and battery that allows them to record the water temperature for up to a year. Using maps of the research area, we were to locate, collect, and replace these data loggers. Since data loggers are glued to the rocks using a waterproof epoxy, our job was to pry the data loggers loose and replace with a new one. Once collected, the data loggers would be transferred to Dr. Helmuth's lab for analysis.

Figure 1.3. Data logger collects water temperature information.

Another tool we used was a motorized device that created gigapans. A gigapan is a 360-degree, panoramic image captured in high resolution. (see Figure 1.4). Dr. Helmuth uses this tool to create highly detailed, virtual tours as way of outreaching to classrooms worldwide. Students interact with the gigapan picture in a variety of ways including zooming in to notice details in the environment and clickable links that provide further information.

Figure 1.4. Motorized device, or gigapan, creates panorama of intertidal zone.

Dr. Helmuth provided many opportunities to explore the intertidal zone. The team spent the first day exploring the area where we collected our data. Dr. Helmuth took the lead as we walked around the beach and rocks. He pointed out features of the intertidal zone; picked up organisms, shared with us names of organisms along with interesting information, then let us hold the organism. Each new step led to some new discovery among the rocks. The excitement in the air was heavy as one person's discovery led to another's fascination.

There was no doubt that for all of us on this trip, it was a rich and meaningful experience. Our lives, both personal and professional, had been positively impacted by this adventure. As classroom teachers, we made connections between our work in Oregon and in our classrooms. We noticed the type of tool used influenced the type and quality of the data collected. We came to understand that doubt leads to inquiry. In Oregon, there was continual problem solving. What worked in the lab did not always work in the field. While in the field it became evident that it was important to be consistent with the data that were collected. If one group collected data according to a specific way, all groups had to collect in the same manner. This consistency helped make the data reliable and valid.

My Tension Led to Further Inquiry

While the connections between the Oregon experience and the classroom were worthwhile, I still felt tension. I wanted to better understand what it was that made the Oregon experience rich and meaningful. I longed for the same rich, authentic learning that took place in Oregon to be experienced by my students.

Fortunately, I had a second opportunity to study alongside Dr. Helmuth in Oregon. This occasion provided me the opportunity to intentionally study learning in a real world context. In so doing, I could better understand how to make learning in my classroom better reflect learning in the world.

Statement of the Problem

The environment Dr. Helmuth created nurtured active participation through inquiry. This enhanced our desire to further understand climate change and its impact on the environment. I came away from the Oregon experience with a deeper understanding of climate change and how it affects organisms in the intertidal zone as a result of inquiring alongside others. I better understood the tools and strategies scientists use to uncover natural phenomena.

I understood I had been provided a unique opportunity to intentionally study my own learning, as well as my fellow teachers from the Center for Inquiry as we learned alongside Dr. Helmuth. I intended to take what I learned about learning from the Oregon experience and apply these features to my classroom in order to create a meaning-rich environment much liked the Oregon experience. I came to understand that Dr. Helmuth created a community of practice in which knowledge was constructed as teachers from the Center for Inquiry positioned themselves as learners who observed and pitched in during a variety of demonstrations. Dr. Helmuth and his colleagues' knowing-in-action adapted their demonstrations to the changing environment, as they exhibited the skillfulness of inquiry. Teachers understood the purpose of their work so they were invested, as they independently took over particular tasks. As I began my own inquiry, the literature I reviewed focused on five areas:

- Apprenticeships
- Authentic learning through inquiry
- Teachers apprenticing under scientists engaging in meaningful scientific research
- Communities of practice
- Classroom communities of inquiry

Apprenticeships. Psychologists and anthropologists who study adult/child relations have observed, in a variety of cultures, that maturation into ways of thinking and doing can be viewed as an *apprenticeship* (Gregory, Long, & Volk, 2004; Heath, 1983; Lave & Wenger, 1991; Mercer, 2002; Rogoff, 1990; Rogoff, 1995; Wells, 1986; Wells, 1999) in which newcomers learn by "observing and participating with peers and more skilled members of their society" (Rogoff, 1990, p. 7). As newcomers transact with their peers, they develop skills, which include the language and tools necessary to perform a particular task, to handle culturally defined problems, and develop solutions within that particular context. Apprenticeships go beyond the interaction between an expert and novice. It is a metaphor for the active participation of newcomers and more experienced individuals as they mutually engage in arranged activities that support participation, and the culturally defined tasks they will contribute towards (Rogoff, 1995).

Mills and Donnelly (2001) and Mills (2014) believe teachers act as mentors who use the apprenticeship model to create learning invitations and to respond to classroom work. Teachers intentionally and systematically demonstrate *how* to learn as they demonstrate *what* to learn (Mills, 2014). They create spaces for students to demonstrate their own processes for learning. Thus, teachers and students move in an out of apprenticeship roles, especially through talk.

Cognitive apprenticeships. Cognitive apprenticeships are another way of expanding the classroom experience by applying apprenticeship pedagogic methods to the teaching of classroom skills such as reading and writing. Cognitive apprenticeships can be described as a model of instruction in which teachers, or another mentor, make their thinking visible (Cheng, 2014; Collins, Brown, & Holum, 1991). According to this model of instruction, "the teacher's goal is to help students gradually take on more complex forms of reasoning and performance through observation and guided practice" (Darling-Hammond, Austin, Lit, & Martin, n.d, p. 146). As students are given opportunities to explore authentic and open-ended topics, classroom activities revolve around the production of some meaningful product. As students work towards the creation of this product, they develop as skilled readers, writers, and mathematicians. Teachers are viewed as coaches whose job is to guide and support the development of student's skills and knowledge by making various processes visible by articulating their reasoning and reflecting on their strategies (Collins et al., 1991).

Authentic learning through inquiry. The push for linking genuine learning experiences from the real world with authentic learning experiences in the classroom has been discussed since Dewey brought our attention to it. Dewey believed that learning was a natural process, embedded in daily life, emerging from our transactions with the world (Fishman & McCarthy, 1998). When one is learning outside the classroom setting, learners are neither passive nor disinterested spectators of life. They are active, willing participants - doing and thinking, wondering and exploring.

Dewey felt that learning in the real world and learning in the classroom should take place through a process known as inquiry (Dewey, 1897; Dewey, 1902; Fishman &

McCarthy, 1998; Kauffman, 1959; Simpson & Jackson, 2003). In its simplest form, inquiry can be described as learning that is driven and inspired by a learner's questions. In another manner, inquiry can be described as a way of knowing in which learners participate in a journey of understanding. Inquirers are willing to "tolerate ambiguity, to sort through multiple perspectives, and to trust abduction – those leaps of insight that totally restructure what is known" (Berghoff, Egawa, Harste, & Hoonan, 2000, p. ix).

Research has also demonstrated that inquiry is to be viewed as a philosophical stance (Berghoff et al., 2000; Dixon & Green, 2009; Mills & Donnelly, 2001; Mills, O'Keefe, Hass, & Johnson, 2014; Monson & Monson, 1994; Ray, 2006; Short & Burke, 1996; Short, Harste, & Burke, 1996) in which teachers and children collaborate as a community of learners as they seek to question and hypothesize about the world around them. Learners solve real problems through authentic problem solving using the language and tools of the discipline being studied. When learning through an inquiry stance, Berghoff, Egawa, Harste, and Hoonan (2000) believes participants must embrace multiple ways of knowing that draw from different sign systems, ideas, and cultural frameworks. Berghoff et al. (2000) argue that the more ways of knowing a learner can access, the richer and more meaningful the learning will be.

Teachers apprenticing under scientists engaging in meaningful scientific research. Researchers believe scientists have an obligation to work alongside teachers as a means of strengthening science education in the classroom (Bower, 2005; Frame, 1992). Bower (2005) feels scientists should model the scientific process. In this manner they can help teachers experience the excitement of science by letting teachers engage in actual scientific exploration. While recent studies have suggested apprenticeship programs for teachers try to increase their understanding of inquiry-based methodologies (Miranda & Damico, 2013), deepen scientific thinking (Buck, 2003), and improve the quality and authenticity of science teaching in high school classrooms (Sadler, Burgin, McKinney, & Ponjuan, 2010; Silverstein, Dubner, Miller, Glied, & Loike, 2009), there is an apparent lack of research connecting apprenticeship program's and their impact on elementary teachers and their classrooms. This study addresses and fills this void in the literature.

Community of practice. A community of practice can be described as a group of individuals who are "informally bound together by shared expertise and a joint enterprise (Cheng, 2014, p. 17). Members share a passion for a joint topic and provide intellectual support that reinforces this passion. Wenger (1998) argues that the community of practice is the curriculum for apprentices (Wenger-Trayner, n.d.), and that knowledge construction is negotiated in the activities of the community. Through legitimate peripheral participation, learners gradually learn the necessary knowledge and skills of the community (Lave & Wenger, 1991).

Communities of practice have been heavily researched within professional organizations (Anyidoho, 2010; Brown & Duguid, 1991; Fuller, Hodkinson, Hodkinson, & Unwin, 2005; Hemmasi & Csanda, 2009; Smith, 2009) as a means of providing organizations with a way of gathering knowledge by connecting individuals who have similar knowledge and interest, and connecting that knowledge with the rest of the organization (Hemmasi & Csanda, 2009). Similarly, communities of practice have been researched in the field of education due to a growing awareness of the social nature of learning and cognition, cultural psychology, and critical anthropology (Haneda, 2006).

Classroom community of inquiry. The term *classroom community of inquiry* describes a particular type of community of practice (Wells, 1999) in which classroom participants (e.g., students and teacher) are actively engaged in the co-construction of meaning "as a community to talk, to listen, to learn, and to rename and remake their world" (Nowell, 1992, p. 17). The relationship between teacher and student can best be described as co-inquirers. Classroom participants use each other to figure how the world works and uncover its meaning (Whitehead, 1976) particularly through dialogue (Lindfors, 1999). Sharp (2007) further describes classroom communities of inquiry as environments in which classroom participants listen and respond to each other in a compassionate manner. Teacher and students build upon each other's ideas through the expression of multiple perspectives. Classroom community members reconstruct these various perspectives and "submit their view to the self-correcting process of further inquiry" (Sharp, 1987, pp. 42-43).

Several studies call for the creation of communities of inquiry within the classroom environment (Franco, 2013; Mercer, 2002; Nowell, 1992; Seixas, 1993; Wells, 1999). These researchers believed that to address educational reform, traditional classrooms needed to be restructured to accommodate inquiry-based methodology influenced by the work of Dewey. Learning is a community-based experience that draws upon inquiry. Teachers inquire alongside students as they seek answers to their questions. In the process, teachers attempt to link the classroom's inquiry to the curriculum so that information is not presented as a set of isolated skills or facts, but rather, as tools to further the inquiry.

In *Dialogic Inquiry*, Wells believes that classroom communities of inquiry are a specific type of community of practice whose focus is on inquiring (Wells, 1999; Goos, 2004). Inquiry-based pedagogy not only affects students but also has a way of equally impacting teachers and administrators who are responsible for the educative environment. A focus on inquiry bridges gaps between all members of the community by creating an equalizing framework in which "individual development and societal transformation are achieved through people working collaboratively with others, both more and less expert than themselves, on questions and problems that arise from practice and are focused on an understanding and improving practice" (Lee & Smagorinsky, 1999, p. 122). Wells draws on classroom examples to demonstrate features of the classroom community of inquiry such as the role of exploratory talk (Barnes, 2008), meaning construction, and collaboration.

Several pieces of research document elementary classrooms that are representative of classroom communities of inquiry (Mills, 2014; Mills & Donnelly, 2001; Parsons, 2009). Parsons (2009) describes how a group of fourth graders developed into a classroom community of inquiry as they became active participants in data collection and analysis, engaged in discussion that encouraged the construction of knowledge, and positioned themselves as moving in and out of apprenticeship roles.

Research Purpose

Mills (2014) argues if we want to learn something new, it is vital that we study how others go about it. When we want to learn the ways of science or history, it is important to study scientists and historians. In this way we can bring more authenticity to the work in our classrooms. Tim O'Keefe articulated these beliefs when he shared his experience learning alongside Dr. Helmuth as a part of the Oregon experience:

> First, the opportunity to work with scientists in a meaningful way gave true purpose to our learning experience. It wasn't an exercise or a field study - it was worthwhile work … there was nothing passive about it. We learned and participated alongside scientists, collecting the same authentic data they were collecting. It was a practical and meaningful apprenticeship … there was meaning and purpose to all that we were taught. As a classroom teacher, I came to appreciate how inquiry for authentic purposes is much more inspiring than simple task completion to learn material (personal communication, Nov. 11, 2013).

The purpose of this research is twofold. Firstly, Dr. Helmuth and his colleagues created a particular kind of authentic, real world learning environment - a community of practice - in which teachers from the Center for Inquiry, including myself, were allowed to take an active and reflective role in the development of our own understanding through active participation in meaningful tasks. We did this under the apprenticeship of Dr. Helmuth and his colleagues. In order to fully understand this community of practice, it was vital that I study features of this learning environment and how knowledge was actively constructed. I intentionally reflected on the learning of my colleagues, and myself, as we worked with Dr. Helmuth. We worked alongside Dr. Helmuth and his colleagues for one week, engaging in the same tasks Dr. Helmuth engages in when studying the affects of climate change on the intertidal zone.

Secondly, once I identified the Oregon experience as a community of practice, it helped me identify my classroom as a specific type of community of practice – a classroom community of inquiry. This identification allowed me to see parallels and make connections between the Oregon experience and my classroom. Identifying these parallels and connections helped me make classroom decisions that supported the authentic, real world learning that took place in Oregon including how knowledge was constructed.

Type of Study and Research Questions

To better understand how learning took place alongside Dr. Helmuth and his colleagues, create similar conditions in the classroom, and document how knowledge was constructed within my classroom, I used qualitative measures designed to investigate the following questions:

- What features of the apprenticeship experience in Oregon nurtured inquiry and new understandings? How can these features influence classroom decisions?
- How was knowledge constructed in Oregon?
- How does my understanding of knowledge construction influence future classroom decisions?
- How was knowledge constructed in my classroom after deliberately transferring and transforming insights from the Oregon experience?

To answer these questions, I relied on qualitative research methods in both the Oregon and the classroom context. I conducted observations and collected field notes in the midst of both contexts and after the fact (Hubbard & Power, 2012). Photographs, audio recordings, and video recordings were collected in Oregon, and in the classroom, so that data could be analyzed on an on-going basis. As data were collected and analyzed, peer debriefing proved vital as it provided an opportunity to test current hypotheses and develop initial next steps (Hail, Hurst, & Camp, 2011; Lincoln & Guba, 1985). Data were analyzed through the constant comparative method (Lincoln & Guba, 1985) in order find emerging patterns in the data.

Overview of Theoretical Framework

My experience in the classroom as a teacher-researcher and kidwatcher (O'Keefe, 1996; Owocki & Goodman, 2002) has influenced me both personally and professionally. During this time, I believe that inquiry is a collaborative process of knowledge construction in which teacher and students inquire together, exploring and investigating the world alongside each other in the spirit of community. In the process of inquiring, new knowledge is constructed when my students and I share our current understanding. Multiple perspectives allow members to reaffirm current thinking, modify existing beliefs, and/or come to new understandings. This belief is founded upon four essential areas:

- Curriculum as inquiry
- The child as curricular informant
- Community
- Children and adults explore together

Curriculum as inquiry. Jerome Harste believes that curriculum is a metaphor for the lives we want to live and the people we want to become (Monson & Monson, 1994; Short et al., 1996; Stephens, Mills, Short, & Vasquez, 2008). By viewing curriculum in this manner, it gives educators an opportunity to look at the kind of future children may face and then collaboratively create the kinds of environments children will need to be productive citizens. This offers a future for children that will have more of a direct impact on their lives instead of a future determined by publishers and their curriculum.

Short et al. (1996) states that “Curriculum as inquiry is a philosophy, a way to view education holistically. Inquiry is education; education is inquiry” (p. 51). This is based on the premise that learning is social and all stakeholders in the inquiry process (e.g., teachers and students) mutually collaborate in the creation of curriculum. Teachers and students play vital roles in the inquiry process as they “follow the logic of an authentic question” (Mills, 2014, p. xix). As teacher and students mutually collaborate, trust forms throughout the inquiry engagement. Diversity is valued as each member of the classroom community brings their unique perspective. These perspectives are vital during explorations because they aid in the generation of new questions. New questions lead to further research; this forms the basis of successful inquiry.

The child as curricular informant. Countering views that curriculum should dominate the decision-making process of classroom teachers (Pearson & Raphael, 2001), Harste, Woodward, and Burke (1984) demonstrated the child should be permitted to inform these processes. In *Language Stories & Literacy Lessons* (Harste et al., 1984), the author’s research focused on observing children in authentic learning experiences. They were interested in the problems children faced and what strategies the child used to solve the problem. Instead of prompting the child, the author’s took cues from the child, supporting the language user instead of intervening (Harste, Burke, & Woodward, 1983). Their research also recognized the importance of establishing personal relationships with their informants. They found the better they knew their informants, and the better the informants knew the researchers, they were capable of observing what children really knew and understood.

According to a child as curricular informant framework, re-positioning the teacher or researcher allowed him or her to observe learning events from a different perspective. In Martens' (1996) research, the child as informant framework helped her document her daughter's literacy over a three-year period. Martens realized that the child's view of literacy is much different from adult's view of literacy. Re-positioning herself to allow her daughter to teach her about literacy, forced Martens to "revalue literacy, what it means to read and write, what it means to be a reader and writer, and what it means to be a literate member of a literate society" (Martens, 1996, p. 7).

When children act as curricular informants, their voice becomes an important contributor to informing the curriculum. Students and their teacher are the dominate voice in classroom decision-making. When teachers allow their students' voice to impact the curriculum, the relationship between teacher and child changes. Teachers re-position themselves as learners, taking cues from the child, and children re-position themselves as teachers, informing the teacher as to their needs.

Community. The work of Ralph Peterson (1992) helped revalue the role of community as a framework in the creation of a caring, supportive learning environment. Peterson (1992) states "community in itself is more important to learning than any method or technique … well-formed ideas and intentions amount to little without a community to bring them to life" (p. 2). Peterson believes that the way human beings learn has nothing to do with remaining quiet, but rather, with a desire to make sense out of their experiences and to share them with others. A community allows learners to do this.

Peterson (1992) describes community as a family since community structures have many of the same structures embedded into family life. For instance, children are not expected to be quiet all day since children are encouraged to be expressive, to collaborate with others, to take risks, and to reflect on their miscues (Peterson, 1992). In a classroom community, these same structures must exist in order to support a healthy place for students to learn. These structures are based on collaboration and cooperation between teacher and student. For example, teachers and students use structures such as ceremony, ritual, rite, celebration, play, and critique (Peterson, 1992). Through the use of these structures, teacher and students engage in authentic experiences much like those of a family. These experiences allow community members to converse with one another and to transact in shared experiences.

Once teacher and students engage in shared experiences, they must have opportunities to make sense of these experiences. The classroom must be an environment that supports talk, because it is through talk that children make sense of the world with the help of others (Lindfors, 1999). As children become competent over time, the community must support their approximations. An opportunity to engage in authentic learning experiences provides situations in which students use talk to approximate and make sense of their world. Authentic learning experiences also allow teacher and student to collaborate as they negotiate meaning. Negotiated meaning not only helps students to reaffirm or modify existing beliefs, but also ensures that multiple perspectives are being heard. Teacher and students provide feedback during these experiences. This allows community members to support the construction of meaning and appreciate community member's contributions.

Researchers have recognized that community can be a generalized term that carries a variety of meanings (Lynch, 2012). This is why researchers have focused on particular kinds of communities within educational settings. Lave and Wenger (1991), and later Wenger (1998), coined the term *community of practice* to describe learning environments where cultural practices are developed and pursued, meaning is negotiated among members, and membership roles are defined through engagement and participation (Aguilar & Krasny, 2011). Though Lave and Wenger's community of practice was not developed for educational settings, it has provided a framework for educators and researchers to use when describing learning within classroom settings (Crafton, Brennan, & Silvers, 2007).

Rogoff, Bartlett, and Turkanis (2001) define community as a set of "relationships among people based on common endeavors – trying to accomplish some things together – with some stability of involvement and attention to the ways that members relate to each other" (p. 10). Building upon this definition, Rogoff et al. (2001) describes the learning environment at the *Open Classroom* school as a *community of learners*. They define community of learners as a community in which "children and adults engage in learning activities in a collaborative way, with varying but coordinated responsibilities to foster children's learning" (Rogoff et al., 2001, p. 7). Adults are responsible for guiding and supporting children's learning, they provide leadership and encourage students to lead, and are expected to learn from students as they engage in shared experiences. This repositions adults from an adult-controlled learning environment to a collaborative learning community involving adults and students.

Children and adults exploring together. Rachel Carson (1956), writer and environmentalist, stated

> If a child is to keep alive his inborn sense of wonder without any such gift from the fairies, he needs the companionship of at a least one adult who can share it, rediscovering with him the joy, excitement and mystery of the world we live in. (p. 46)

As an environmentalist, Carson was an advocate for adult-child relationships in which adults guided children into helping them develop a sense of wonder and awe concerning the natural world around them. Helping children develop a sense of wonder should not necessarily focus on identification, since most adults lack the knowledge to identify organisms in their particular backyard or neighborhood. She felt adults' responsibility was to develop children's sense of wonder by guiding their senses; heightened senses often translate into a heightened awareness. When the child is aware of their surroundings they are more apt to wonder, explore, and investigate. The adults' responsibility is to apprentice children into developing this sense of wonder.

In Mills' (2004, 2014) work, she demonstrates the importance of adults and children exploring together through an inquiry stance. Classrooms at the Center for Inquiry often begin each day with explorations. During explorations, adults explore alongside children into those things they are passionate about. For example, Mills shares a story about Tim O'Keefe's classroom in which students reconstruct the skeleton of a dead bat that had been buried for five months. During the reconstruction of the bat, Tim explored alongside his students, yet led "from behind by talking scientist to scientist, teaching into and out of his students' connections and questions" (Mills, 2014, p. 135). In Susan Bolte's classroom at the Center for Inquiry, she explored alongside her kindergarten students during a unit on space and the moon. Knowing questions were an important part of their study, Susan demonstrated the importance of asking questions, eventually inviting them to collaborate in the creation of more questions. As they progressed through the unit, Susan explored alongside her students using her personal Moon Journal, non-fiction books, and demonstrated note taking to remember important facts (Mills, 2014).

Significance of the Study

Wells (1986) states that every teacher needs to become their

> own theory-builder, … a builder of theory that grows out of practice and has as its aim to improve the quality of practice. For too long, 'experts' from outside the classroom have told teachers what to think and what to do (p. 221).

I believe this research takes on the challenge of growing new beliefs that emerge from my classroom practice.

Although inquiry-based methodologies and communities of practice have been documented individually within classrooms, this study represents the first teacher-research I am aware of connecting these frameworks, to create a description of how classroom communities of inquiry construct knowledge. Embedded within this framework is the notion of apprenticeship learning. While other studies have documented the apprenticeship experiences of teachers working alongside scientists (Sadler et al., 2010), this study contributes to the research by documenting how a classroom teacher made connections between learning in an apprenticeship experience and his classroom community of inquiry. Noticing and naming features of the apprenticeship experience in Oregon allowed me to make better informed decisions concerning how I apprenticed students into constructing their own knowledge in the context of my classroom. The findings and implications from this research could contribute to scientists creating apprenticeship programs for teacher preparation and professional development, inquiry-based methodology, communities of practice, classroom communities of inquiry, teacher research, and daily classroom practice.

CHAPTER 2

Theoretical Framework and Review of Pertinent Literature

When teacher-researchers inquire into their classroom practices, it is important to look towards a theoretical framework that integrates their personal and professional beliefs, while providing a framework that provides explanations, helps teacher-researchers understand various phenomena, and challenges and extends existing knowledge, during the course of their research. My understanding of a curriculum focused on inquiry, the child acting as a curricular informant, community, and children and adults exploring together, is heavily influenced by a sociocultural framework and inquiry as a philosophical stance (see Figure 2.1). Working within this theoretical framework allowed me to make connections between learning within the Oregon

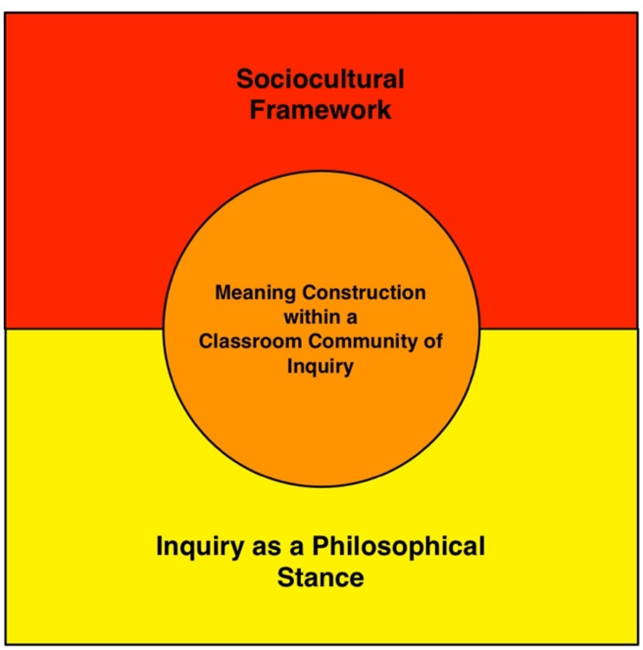

Figure 2.1. Theoretical framework.

community of practice and learning within the classroom context. Therefore, this framework provided the lens I used to answer the following research questions:

- What features of the apprenticeship experience in Oregon nurtured inquiry and new understandings? How can these features influence classroom decisions?
- How was knowledge constructed in Oregon?
- How does my understanding of knowledge construction influence future classroom decisions?
- How was knowledge constructed in my classroom after deliberately transferring and transforming insights from the Oregon experience?

Sociocultural Framework

When discussing any sociocultural framework, especially within an educational context, it is important to begin with Vygotsky who argued that all human development, including how one acts, thinks, feels, and communicates, are shaped through our engagements in culturally valued activities, using the particular tools of that culture, and developed over time (Wells, 1999). This development is highly influenced when individuals participate in particular activities alongside others. In other words, we become who we are when we engage in culturally valued activities, with the help of others, and the mediating artifacts that are available. During these situated activities (Lave & Wenger, 1991), the problems and the artifacts are changed, as well as our understanding of how to use various resources to aid our thinking and doing. Individuals learn to “adapt, extend, and modify both the intellectual and material resources in order to solve the problems encountered” (Wells, 2001a, pp. 177-178) when they work together.

According to this account, Wells believes there are three features that should be further discussed in order to fully understand Vygotsky's theory.

First, Vygotsky developed the concept of the *zone of proximal development* based on characteristics of novices learning alongside more experienced learners. According to Aubrey, Jasper, and Verges (2009), the zone of proximal development represents a learner's potential cognitive development. Within this zone, students are cognitively prepared to learn a particular task with the guidance of a more knowledgeable cultural member who can provide support for the novice's evolving understanding. The zone of proximal development is not a fixed characteristic of the learner, but instead, is specific to the particular task the learner is engaged in, the cultural artifacts available, and the relationship between the learner and the individual providing guidance (Wells, 2001a). Thus, it is the zone of proximal development that should be the target of all teaching since instruction is always ahead of the child's development, and often nudges the development forward (Vygotsky, 1987). To address the needs of the learner, the individual providing support must be responsive to the learner's needs, their goals, and take into consideration the learner's development. Doing this helps the learner achieve their goals and provides additional support, which helps the learner to independently accomplish similar tasks in the future.

Second, Wells (1999, 2001a) believes the zone of proximal development is not relegated to just students - the teacher learns in the same manner. Whenever individuals collaborate in a particular cultural activity, each person assists each other and each person contributes to the particular problem. In fact, according to Wells (2001a), the zone of proximal development is a learning experience that involves all participants. For the teacher, while teaching involves preparation and instruction, to truly be effective within the zone of proximal development involves the co-construction of knowledge with children and the improvisation of judgment concerning how to best support young learners within the particular context (Lee & Smagorinsky, 1999). When teachers value and embrace learning within zones of proximal development, including learning within their own zones of proximal development, they set out constructing their own knowledge of teaching through reflective practice, such as learning alongside other teachers in the spirit of inquiring into their own teaching practices. This teacher-research places an emphasis on community and collaboration – teachers providing support for one another as they develop solutions for classroom problems that move beyond "standard practices recommended by experts outside the classroom" (Lee & Smagorinsky, 1999, p. 329). This emphasis on the co-construction of knowledge, with its emphasis on community and collaboration, moves into the classroom as students act as co-researchers and co-collaborators through inquiry (Mills, O'Keefe, Hass, & Johnson, 2014). When this takes place, Wells believes a "more equal and reciprocal interpretation of the concept of learning and teaching in the zpd [zone of proximal development] is born" (Wells, 1999, p. 330).

Third, Vygotsky placed great emphasis on the importance of artifacts in mediating activity. While artifacts entail tools such as scissors, paper, forks, and computers, he also believed that cultural artifacts included signs and symbols such as speech, reading, writing, and various modes of visual representations such as diagrams and models (Lee & Smagorinsky, 1999; Wells, 2001a). Vygotsky understood that signs and symbols were the real transmitter of culture (Davydov & Kerr, 1995) with speech being the most powerful and versatile of all signs and symbols (Wells, 2001a). For Rogoff (1990), she believes that speech is of great significance, but instead of emphasizing its importance, we should look more broadly at communication, which includes verbal and nonverbal signs. Since signs have no real value outside the context in which they are used, to master the use of signs entails individuals participating in practices in which the sign plays a mediating role. It is through this participation that novices learn to construct their own understanding of the situation with the guidance of individuals who have more experience (Rogoff, 1990; Lave & Wenger, 1991).

Apprenticeships. Important to Vygotskian beliefs and a sociocultural framework, is the idea that children learn cultural ways of being as they apprentice alongside more experienced members of a cultural group. Gregory, Volk, and Long (2004) states that "Crucial to a sociocultural framework…is the role of the mediator (a teacher, adult, more knowledgeable sibling or peer) in initiating children into new cultural practices or guiding them in the learning of new skills" (p. 7). As children apprentice into particular tasks of that culture, they learn how to use the tools and language through direct demonstration.

Rogoff (1990) coined the term *guided participation* to refer to "the child as co-constructing meaning with an adult" (Chen & Gregory, 2004, p. 121). It is not just adults that children co-construct knowledge with, but any companion or caregiver such as siblings, friends, teachers, or relatives. According to this model, children learn as apprentices alongside more experienced members of a cultural group (Rogoff, 2003). For instance, in Robertson's (2004) work with young bilingual children involved in early literacy learning experiences, she believed children constructed knowledge as they interacted with others as they used literacy in authentic and meaningful ways.

Paradise and Rogoff (2009) believe learning that takes place within an apprenticeship often represents a formalized relationship between the expert and novice. The context in which apprenticeship learning takes place often involves a workspace or other clearly defined setting. Training involved in this setting is often in a specialized area of knowledge. This knowledge passes from expert to novice in a formalized manner, and the roles of expert and novice are clearly defined.

Observing and pitching in. Paradise and Rogoff (2009) feel that learning through observing and pitching in represents learning that "has a more flexibly defined interactional and collective organization in which learner and expert can sometimes interchange their roles" (p. 105). When children contribute through observing and pitching in, they contribute to the community much like adults. Their motivation to contribute is driven by their need to participate in valued activities that other members of the community contribute towards. Their goals are evident and they understand the purpose of their work thus, much of the responsibility for learning falls on the part of the learner. In the process of accomplishing the task, the learner develops his or her own approaches to learning instead of following a predetermined set of instructions (Paradise & Rogoff, 2009).

Communities of practice framework. Lave and Wenger (1991) and later Wenger (1998) introduced the communities of practice framework to the sociocultural literature out of frustration with learning theories that addressed learning as an individual entity, separate from participation, and resulting only through teaching (Smith, 2009).

Communities of practice can be defined as a place of learning where practice is developed, with others, who share a similar concern or passion (Aguilar & Krasny, 2011; Wenger, 1998), and who associate on a regular basis (Lockwood, 2013). Crafton, Brennan, and Silvers (2007) states that communities of practice exist everywhere and we are often participants in numerous communities of practice such as church, Boy Scouts, a sports team, or book club. To be defined as a community of practice, three dimensions of practice must be in place: (1) mutual engagement among participants, (2) a joint enterprise through negotiated meaning, and (3) a shared repertoire specific to that community.

Mutual engagement. As individuals work together, they negotiate meaning and work to reach agreements that form the basis of mutual engagement (Anyidoho, 2010). While communities of practice are not problem-free environments, mutual engagement helps build and create relationships among its members. Since members work toward common goals, participating in shared practices helps to connect participants to each other. Mutual engagement involves not just the competence of the individual, but through personal connections, the community of practice draws multiple perspectives from its participants (Wenger, 1998). Thus, communities of practice focus on heterogeneity since problems to be solved rely on multiple voices and perspectives.

Joint enterprise. Anyidoho (2010) states that the basis of any community of practice is the coming together of people who have a commitment towards a common enterprise, or undertaking. The participants negotiate this enterprise as they respond to various situations, as they work towards the common endeavor. Wenger (1998) says that

> individual situations and responses vary, from one person to the next and from one day to the next. But their responses to their conditions – similar or dissimilar – are interconnected because they are engaged together in the joint enterprise … they must find a way to do that together, and even living with their differences and coordinating their respective aspirations is part of the process (p. 79).

Even when outside sources mandate particular practices, the community comes together to respond to the particular mandates. Thus, community members have power to respond to outside practices, respond to the situation, and make it their own according to their mutually agreed upon joint enterprise.

Shared repertoire. Developed out of their engagement in joint enterprise, communities of practice create a shared repertoire, which is used to negotiate the construction of meaning. Wenger (1998) used the term *repertoire* to reflect the historical account and ambiguity of such shared practices. This shared repertoire is important because it represents a "deposit of knowledge and norms that sustain a community" (Anyidoho, 2010, p. 326). Anyidoho (2010) continues to explain that this shared repertoire is important because it creates continuity since communities can sometimes have weak relationships among its members. A shared repertoire helps to keep commonality with its members over time.

Wenger (1998) explains that a shared repertoire is heterogeneous, reflecting the members of the particular community of practice and the joint enterprise they negotiate. The shared repertoire of a community of practice can include a variety of resources. These include celebrations and rituals, words or common phrases, stories, ways of thinking and constructing knowledge, and symbols and signs. The shared repertoire includes discourse, how the discourse is negotiated, and how discourse is used to construct and demonstrate meaning.

The negotiation of meaning through practice and reification. At the heart of communities of practice lies the belief that "practice is about meaning as an experience of everyday life" (Wenger, 1998, p. 52) and "that knowledge, and therefore learning, [are] embedded in cultural practices" (Hoadley, 2012, p. 288). As an example, Orr's (1990) work of Xerox copy repairmen discusses a situation in which the repairmen could not rely on manuals and standard operating procedures to fix a particular problem. Instead, knowledge was co-constructed from the stories the repairmen shared based on their everyday experiences and mutual problem solving.

Wenger (1998) believes that living in the world is a constant process of negotiated meaning. He intentionally uses the term *negotiated* to suggest that meaning is a matter of continuous transaction with the world, of give-and-take. By transacting with the world, individuals do not make meaning independent of the world, but nor does the world impose its meaning upon the individual. Meaning is not constructed from scratch. It is an active and productive process of negotiation between meaning within the particular culture, and the knowledge the individual has come to understand through experience.

Communities of practice empower its members to negotiate meaning as they engage in a joint enterprise. For instance, Miles' (2007) work explored the Creative Partnerships project, which attempts to include socially, excluded young people by creating positive learning experiences through performance training. He argues that these socially excluded young people, including the volunteers at the Creative Partnerships project, created a community of practice through its joint enterprise in performance. The meaning endowed in rehearsal, performance, and practice became negotiated as these young people introduced biographical elements into their performance. According to Miles (2007), "learning is an evolving, continuously renewed set of relations centered around participation in social practice" (p. 509).

Reification. While less common than participation, Wenger uses the term *reification* to describe practice that takes our reflections, thoughts, ideas, and understandings, and creates some item to represent those reflections, thoughts, ideas, and understandings (Wenger, 1998). When communities of practice create items which attention can be focused upon, meaning can be negotiated around that object. Students and teachers use that object as a focal point for the co-construction of knowledge. Since communities of practice produce shared repertoires of tools, symbols, and language, these concepts are often reified during practice to create something that is concrete (Wenger, 1998). For example, Wenger (1998) describes the medical claims filed by claims processors as a form of reification because they involve "a complex web of conventions, agreements, expectations, commitments, and obligations" (p. 59) all congealed onto a standardized form.

Reification is meant to cover a wide range of activities that include any kind of making or designing, such as through diagrams and models, naming, and describing. Wenger (1998) believes that reification takes up much of our energy because humans reify continually. Everything from writing down our thoughts into a journal or making a shopping list, creating advertisements, writing a signature, creating a recipe, or making lesson plans, all entails reification. In each of these instances, human experience and practice is brought together to create some concrete item. This is why Wenger believes that reification is so important – it shapes our experience (Wenger, 1998). The use of tools to perform an action changes the nature of that action, and can also shape the lens from which we view the world.

For Wenger (1998), while participation refers to a process of taking part in some activity, including the reification of our thoughts and ideas into object, he is clear that participation also involves the relationships that reflect this process. In other words, participation involves "action and connection" (Wenger, 1998, p. 55). Wenger continues to describe participation as "the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises" (p. 55). Through this active participation, the learner begins to identify with the community and develop relationships with the participants.

Legitimate peripheral participation. To further illustrate the point that the negotiation of meaning takes place through active participation within communities of practice, Lave and Wenger (1991) described newcomers coming to know through active participation within a family or community of practice as *legitimate peripheral participation*. As newcomers participate in cultural activities, they work alongside those with more experience who provide guidance and support. As newcomers learn the necessary knowledge and skills, they move from peripheral participation to full participation. Thus, learning is viewed not as the acquisition of knowledge but a process of social participation (Smith, 2009).

As an example, Lave and Wenger (1991) describe Vai and Gola tailors as they enter and leave their apprenticeships. Master tailors run shops that include supervising apprentices. Apprentices learn for a period of five years, observing the master tailor, journeyman, and other apprentices at work. While master tailors traditionally created men's trousers, they make other garments. The list of garments created a curriculum for apprentices as they first learned to make hats and children's clothes. Eventually the apprentice moved towards higher end formal garments. For Lave and Wenger, describing the learning amongst Vai and Gola tailors as *learning by doing* provided an inadequate explanation of how these apprentices learned their craft; it did not take in to account the relational aspect of participation.

While the apprenticeship model remains an important component of learning, Lave and Wenger's (1991) view of learning through legitimate participation provides a broad, theory of learning based in social practice. They felt that "learning is not merely situated in practice – as if it were some independently reifiable process that just happened to be located somewhere; learning is an integral part of generative social practice in the lived-in world" (Lave & Wenger, 1991, p. 35). They further stated, "legitimate peripheral participation provides a way to speak about the relations between newcomers and old-timers, and about activity, identities, artifacts, and communities of knowledge and practice" (p. 29). Since Lave and Wenger believe that learning is an important component of social practice, participating in communities of practice will eventually involve learning at some point. Included within this, active participation in the social practice can be viewed as belonging to the community. As Fuller, Hodkinson, Hodkinson, and Unwin (2005) shares, "It is the fact of becoming a member that allows participation, and therefor learning, to take place" (p. 51).

Vygotskian views of the importance of artifacts mediating activity, novices learning alongside more experienced members, and the zone of proximal develop as being relevant towards students and teachers, formed a strong sociocultural foundation of how I understand and explain various classroom phenomena. These views formed a foundation for coming to understand the importance of community in helping to co-construct cultural knowledge.

Inquiry as a Philosophical Stance

Many researchers believe that inquiry has moved from a set of skills to a philosophical stance (Mills, 2014; Monson & Monson, 1994; Short et al., 1996; Wells, 1999). This philosophical view of teaching and learning “promotes intentional and thoughtful learning for teachers and children” (Mills & Donnelly, 2001, p. xviii). According to this stance, teachers and children collaborate as they seek to question and hypothesize the world around them. Learners solve real problems through genuine problem solving using the language and tools of the real world. All participants have equal access to the curriculum thus, all voices are valued and respected. Growth in learning is not a result of the end product of an activity but as a result of risks and approximations attempted along the process. Teacher and students participate in decision-making matters. Since decision-making is shared by all, power is shared equally among members of the classroom community.

Inquiry cannot be found “in a costly kit containing cassettes, workbooks, activity cards, and a teacher’s guide, nor is it a software detective game” (Tanner, 1988, p. 471). It is an epistemology, a theory of knowledge, that is grounded in beliefs such as democratic principles (Dewey, 1923; Mills et al., 2004), social justice (Freire, 1970; Lewison, Leland, & Harste, 2007), social constructivism (Wells, 1995), and sociocultural theory (Gregory et al., 2004; Wells, 1999). In fact, Mills et al. (2014) states that “inquiry is a stance that promotes authentic, intentional, and systematic learning" (p. 36). This means that learning cannot be something that is absorbed like a sponge absorbing liquid. Inquiry is an active process in which the inquirer must transact with the physical environment, in some way, until their problematic situation is resolved (Bruner, 1961). Based on this definition, inquiry serves as a metaphor for the active construction of knowledge and understanding.

Inquiry is an active process of knowledge construction. Wells (1995) believes that the most effective way inquiry in the real world takes place is when the learner is faced with a specific question, which arises from their personal inquiries, such as wanting to know more about climate change or global warming. To inquire in the world, knowledge is not simply absorbed from information that is presented. Knowledge is actively constructed as the learner attempts to make sense of existing information.

Systematic, careful observations. When learning anything new, Mills (2014) believes individuals seek to understand first by making systematic, careful observations, regardless of the content. In other words, "Observation is the key to all learning" (Short et al., 1996, p. 55). Mills points out that observing is a natural stance scientists take when engaging in scientific problem solving. But this stance is not unique to scientists (Mills, 2014), and that all individuals who place themselves in the position of learner, observe as a part of their first instinct in learning. Important to this stance is that the tools and strategies of a particular discipline are learned in the process of observing through the lens of the people associated with a particular discipline. As an example, Mills (2014) discusses Tameka Breland's fifth-grade classroom at the Center for Inquiry. During a unit of study on immigration, Tameka asked students to observe primary documents from the perspective of a historian. Students made systematic, careful observations of a variety of photographs and recorded what they noticed. Next, students shared their observations and created a list of general classroom noticings. The talk around the photos nudged students to inquire more deeply into what they noticed. Over time, their observations and noticings became more sophisticated.

Noticing and naming. Essential to the notion of making systematic, careful observations is noticing and naming (Johnston, 2004; Mills, 2014). Johnston (2004) believes that while noticing and naming is an important characteristic of what it means to be human, it is a crucial aspect of how learners construct knowledge. Noticing and naming refers to observing particular signs and symbols that represent meaning in a particular discipline, then giving names to those signs and symbols. To give names to something means the learner understands what those signs and symbols represent. For example, in *Wondrous Words* by Katie Wood Ray (1999), she states that in order for young writers to write well, they should attend to the craft of professional writers. Young writers must notice the techniques professional writers use in their writing, and give names to those particular techniques so that those techniques become a part of the young writer's craft. When young writers notice that Cynthia Rylant uses *repeating details* in *The Relatives Came* (Rylant, 1985), they are more likely to use this technique in their own writing because they understand how this writing technique is used and for what purpose.

Noticing and naming is a powerful characteristic of the apprenticeship model (Johnston, 2004; Rogoff, 1990). Johnston (2004) believes that the power of noticing and naming, as a part of the apprenticeship model, lies in the acquisition of language unique to that discipline. Noticing and naming nudges novices to be aware of their surroundings, and to use their language to impact their environment. Johnston (2004) feels it is the teacher's job, as expert in the apprenticeship model, to create experiences in which they can help the child notice things. The more children notice, the more they bring attention to information that is pertinent to what is being studied.

Pose and investigate questions. Mills (2014) also believes when we learn anything new, we pose and investigate questions. When students pose and investigate questions, they reposition themselves "from passively receiving information to actively constructing, owning, and acting on their learning" (Mills, 2014, p. 27). Acting on our learning contributes towards identifying those things we know and understand. Even though we are able to identify those things we understand, participating in this process of knowing means being open to what me may believe to be correct is wrong, or what we believe is not inclusive of the whole picture (Mills, 2014). This is why posing and investigating questions about what we may understand, especially from different perspectives, as an important characteristic of constructing knowledge.

Posing and investigating questions from multiple perspectives. In *Opening Minds*, Peter Johnston (2012) asks readers to consider two questions which might be found in a classroom test on the Civil War. One question asks the reader to name the three main reasons for the Civil War, and the second question asks the reader, from the perspective of a white male living in the twentieth century, what the main reasons for the Civil War are. Johnston believes that the first question implies a single, correct answer. The second question might begin an in-depth conversation, which may invite perspectives from other groups during the Civil War (Johnston, 2012). It implies there is no single answer, and that multiple perspectives must be considered in order for true understanding to take place. In the words of Lewison, Leland, and Harste (2007), “Part of our responsibility to inquiry means understanding that all knowledge is constructed from particular perspectives and that getting at multiple and contradictory viewpoints enriches our perceptions of the world” (p. 17).

Mills (2014) believes teachers need to create environments in which children look at the world through multiple perspectives. Instead of teaching reading, writing, and math, children should be encouraged to look at the world as readers, writers, mathematicians, scientists, artists, etc. By looking at the world through those particular lenses, children “deepen and broaden their learning simultaneously” and reposition themselves from “passively receiving information to actively constructing, owning, and acting on their learning” (Mills, 2014, pp. 26-27). When children understand that there are multiple perspectives on a topic, they are more willing to ask questions such as, “Whose voice is heard?” or “Whose voice is missing?” (Mills, 2014).

At the same time, students build identities around these perspectives. They begin to view themselves as readers, writers, and mathematicians. Johnston (2004) says that children notice “characteristics of particular categories (and roles) of people and developing a sense of what it feels like to be that sort of person” (p. 23). Viewing the world from multiple perspectives allows children to try different identities in different contexts. In so doing, the child takes up a position in regards to what they are studying (Johnston, 2004). This facilitates children posing and investigating questions from those particular positions and identities.

Posing and investigating questions invites multiple perspectives. Short, Burke, and Harste (1996) believes that “Curriculum should not so much prioritize a perspective as invite multiple perspectives” (p. 341). To support this belief, a dialogic classroom community must be established in order to pose and investigate questions that invite multiple perspectives (Johnston, 2012; Mills et al., 2004; Wells, 1999). These classrooms do not emphasize the exchanging of facts, but the creation of an environment in which open discussion and extended debate among students and teacher is highlighted (Mercer, 2002). In fact, Lewison et al. (2007) believes that questioning, which invites multiple perspectives on a topic, is profoundly democratic. When classrooms refrain from inviting multiple perspectives, they run the risk of moving towards the banking concept of education (Freire, 1970) in which all knowledge and perspectives of a topic are controlled by the teacher.

When students engage in conversations in which multiple perspectives are encouraged, they come to understand the tentative nature of knowledge (Mills, 2014; Mills et al., 2014). The tentative nature of knowledge leads to uncertainty. Yet, this uncertainty of knowledge that can exist in any conversation, is what sustains the inquiry. Dialogic classrooms create spaces in which students use each other to further their understanding as they inquire (Johnston, 2012; Lindfors, 1999). As a result, the construction of knowledge does not happen in isolation, but is socially constructed as students inquire and research their questions.

Opportunities for reflection. Once students have been invited to pose and investigate questions, students need opportunities to reflect. Boud (2001) believes that reflection involves taking experiences, and engaging with those experiences in some manner, that helps us makes sense of what has occurred. Reflection often entails exploring messy or muddled thoughts, and confusing events, and focusing on the emotions that accompany such events such as “This is frustrating” or “Aha, I get it!”. It can take place in a variety of manners such as through personal activities like writing journals (Sloan, 1991; Boud, 2001) or drawing (daSilva, 2001), as part of a larger group such as through think alouds (Zimmermann & Keene, 1997; Keene, 2012), or integrated as a part of each curricular structure (Mills, 2014).

Boud (2001) feels that much of the reflection teachers engage students in typically takes place after an event or activity, which could paint learners as being passive respondents to the particular event. To counteract this idea, Boud (2001) believes that reflection should be woven throughout the day, and should be considered during three particular occasions: in anticipation of events, in the midst of the event, and after the event. Reflection truly benefits the learner when they have opportunities to work alongside each other. When students work in pairs or in small groups, they transform existing views of their world and confront old patterns of learning (Boud, 2001). This leads to learners who can collaborate alongside others in a give and take manner. Thus, these students learn to critically reflect on their experiences together, and use their experiences to socially construct knowledge.

Knowledge is socially constructed through inquiry. The heart of constructing knowledge lies in the collaborative nature of inquiry. Knowledge on the part of the learner is never constructed in isolation. Rather, it is co-constructed, or negotiated, with other participants (Wenger, 1998; Mills et al., 2004; Wells, 2006). Wenger (1998) says that as learners engage with other learners, living in the real world becomes a constant process of negotiated meaning. As learners transact, usually through dialogue, new knowledge is achieved as individuals attempt to "solve a problem, construct an explanation, or decide on a course of action" (Wells, 2006, p. 28). This is often referred to as collaborative inquiry.

Collaborative inquiry. Wells (1995) believes that collaborative inquiry is the co-construction of meaning, usually through dialogue, between the teacher and learner, "in relation to the tasks and topics that are of mutual interest and concern" (p. 235). The teacher and learner bring their existing knowledge to the particular situation. As collaborators transact within a unique learning context, knowledge is constructed and reconstructed between those engaged in the investigation, using whatever cultural resources necessary for carrying out the inquiry. This knowledge is only truly known, when put into practice by the collaborators, in actual solving of specific problems (Wells, 1995; Wells, 2001a). Once put into practice, this knowledge can be developed and modified by the participants in order to meet the demands of the problematic situation. Thus, knowledge is co-constructed amongst collaborators as "learners actively [engage] in constructing meanings from personal experience and from the information that is made available to them" (Wells, 1995, p. 238) as they participate in social activities.

Similarly, Mills et al. (2014) states that collaborative inquiry is about creating curriculum for and alongside students. At the Center for Inquiry, collaborative inquiry lies at the heart of the schools' belief system and permeates through each classroom. One way teachers at the Center for Inquiry link learning at school with learning in the real world is by engaging kids in authentic research. Students are encouraged to "pose questions, make careful observations, interpret them from their unique perspectives, and then share their findings" (Mills et al., 2014, p. 37). By doing this, students position themselves as mentors, collaborating alongside the teacher. Mills (2014) feels that teachers are often blinded by their experience, their focus on curriculum materials and standards, and cultural biases. When students are allowed to collaborate alongside the teacher, their perspective on the world opens up new possibilities of noticing and naming the world, which helps the teacher grow in knowledge. Students offer their teacher the opportunity to grow in understanding as children question what teachers believe to be true (Mills et al., 2014). When children are consciously taught the skillfulness of inquiry, "they co-construct knowledge and enrich everyone's understanding, tall and small" (Mills et al., 2014, p. 37).

Semiotic apprenticeships. Wells (1994) believes the metaphor of semiotic apprenticeships is apropos to learning, and the teaching relationship between students and teacher, because it enacts inquiry within a sociocultural framework. First, apprenticeships emphasize that learning best occurs in the course of purposeful and relevant activities that contribute to the life of the community. Second, apprenticeships embrace the complexity of "real-life activities and of the need for collaboration between participants with different kind and levels of expertise" (Wells, 1994, p. 14). Third, with its roots in traditional craft practices, apprenticeships as a metaphor emphasize the importance of learning to use the cultural tools, developed over time, that help achieve the goals of a particular activity. It is this third point Wells believes emphasizes the semiotic nature of learning (Wells, 1999).

According to Wells (1999), the teacher's prime responsibility is to apprentice learners into various ways of making meaning that are valued by that culture. These *tools*, whether material or symbolic, may include: 1) beliefs and values about what activities are worthwhile to participate in, 2) knowing the practices involved in those activities, and 3) proficiency and knowledge of the various artifacts used to construct meaning. To do this, the teacher must engage learners with mandated curriculum, and appropriate it as best as possible, so that learners use this knowledge as a "personal resource for their own current and future purposes, and so that they may be productive members of the society in which they are growing up" (Wells, 1996, p. 83). Teachers help apprentice learners into the semiotic nature of learning by negotiating mandated curriculum with themes or curricular units of study (Wells, 1999; Mills, 2014).

Wells (1995, 1996) feels that teachers need to concentrate on two levels of teaching, the macro and the micro. At the *macro* level, the teacher is responsible for selecting curricular themes or units of study based on their knowledge of their students' and their interests. The topic chosen is designed to engage students in careful and systematic observations, pose and investigate questions, and provide opportunities for reflection (Mills, 2014). The teacher anticipates the semiotic resources that are relevant to the topic such as books or computers, that are needed to support *minds-on work* (Wells, 1995). As the topic is researched, the teacher mediates the pace of the theme or unit of study alongside students by adding or removing parts according to interest and time. The teacher is responsible to providing time to accomplish tasks and bring the study to a meaningful conclusion, and evaluating student work according to cultural norms. At the *micro* level, teachers are responsible for working alongside small groups of students or with individuals in helping them achieve negotiated goals. It is at the micro level where the teacher is best able to practice Vygotskian principles such as apprenticing students into cultural ways of living and learning (Rogoff, 1990; Wells, 1999) and working with students within their zone of proximal development (Vygotsky, 1978; Wells, 1999).

If education is going to concern itself with the preservation and development of society, then it must nudge students to take active roles in the development of their full potential. This means that children must develop the necessary knowledge and skills that are important for full participation in society. Wells (2001a) believes that in order to participate in a democratic society, schools must create environments that initiate children into the values of that society, as well as helping them attain the knowledge necessary for contributing to that society. This translates into schools and classrooms becoming more democratic (Mills et al., 2004), and more critical to how knowledge is constructed (Wells, 2001a). For Dewey (1923), this meant that students need to be given the opportunity to develop this knowledge and skill through an active process of inquiry. But inquiry cannot be nurtured in just any classroom environment – it is a collaborative classroom community that provides the ideal environment for inquiry (Wells, 1999; Mills & Donnelly, 2001; Wright, 2015) since this environment best typifies democratic principles needed for inquiry to flourish (Johnston, 2004).

Classroom Community of Inquiry

Charles Peirce felt inquiry was a democratic process because the settlement of beliefs should not rely on an individual, but involve many participants who have a vested interest in the particular inquiry. Peirce referred to these participants as a community of inquirers, whose responsibility was not to settle beliefs, but to continue the inquiry (Talisse, 2004). Participants in this community engaged in *belief correction* – the process of a constant revision of thinking through the testing of beliefs when compared to what is observed (Talisse, 2004). During this process of belief correction, the community of inquiry agrees upon a shared repertoire of tools and methodologies that will help resolve the doubt (Cunningham, Schreiber, & Moss, 2005).

Like Peirce, Dewey believed inquiry is inherently social. The resolution of doubt through inquiry does not take place in isolation. The problematic situation is often resolved with the help of others. Dewey argued these individual inquirers are members of communities of inquiry, bound by certain agreements and responsibilities (Peirce, 2005; Schön, 1992). Once inquiry takes place, the community of inquirers enter into a contract such that they will stand by their results until further reasons lead them to doubt, or problematic situations occur.

Individuals such as Rogoff et al. (2001) have recognized the importance of *community* in education. For instance, Rogoff et al. (2001) writes about the Salt Lake City Open Classroom or OC. At this school, children and adults participate in learning activities in what they refer to as *communities of learners*. They state that communities of learners develop practices specific to that culture such as practices and traditions that transcend the individuals involved. Adults guide the participation of young leaners as they choose activities to explore, develop decision-making skills, problems solve, and share everyday observations.

Well's (1999) problem with the expression *communities of learners* is the emphasis on learning as the object of the community's practice. Instead, the focus should be placed on participating in practices that achieve some other object in view. As a result, Wells (1999) believes "the necessary skills and knowledge are learned as mediating means for and in achieving the object of the activity" (p. 123). As an example, if the object of the activity is to inquire into ornithology, then young learners will learn the necessary skills and knowledge of ornithology. Having ornithology, not learning, as the object of the activity, young learners develop the strategies and language of the discipline, can pose and investigate questions from the perspective of ornithologists, and access a variety of primary and secondary sources unique to ornithology (Mills, 2014). Artifacts such as models, diagrams, data collection charts, creation of a script or play, or multi-media presentations are created under the guidance of the teacher. Through these artifacts students learn different modes of knowing. Wells refers to this as the *spiral of knowing* (Lee & Smagorinsky, 1999). Differing modes of knowing are viewed as a means of carrying out inquiry, and not the end result.

Over time, notions of communities of inquiry made its way into the classroom. The term *classroom community of inquiry* is used to describe classrooms in which participants actively engage in the construction of meaning "as a community to talk, to listen, to learn, and to rename and remake their world" (Nowell, 1992, p. 17). In fact, Mercer (2002) challenges teachers to be co-creators of a "particular quality of intermental environment – a community of enquiry – in which students can take active and reflective roles in the development of their own understanding" (p. 9). Wells (1994, 1999) has discussed classroom communities of inquiry as being parallel to the adult-oriented learning of professionals that take place in communities of practice (Wells, 1994). He believes that classroom communities of inquiry are a specific type of community of practice, as developed by Lave and Wenger, since it is rarely possible to create the same activities that exist in professional communities of practice (Lave & Wenger, 1991).

The primary means of constructing knowledge in classroom communities of inquiry takes place through talk (Mercer, 2002; Wells, 1995; Wells, 1999). Talk allows inquirers to reshape existing knowledge in light of new information. It brings children together in particular social situations and allows them to "acquire and practice ways of using [talk] to think collectively" (Mercer, 2002, p. 11). In classroom communities of inquiry, this enables children to play with the language of inquiry, to think collectively with other inquirers, and to use others to go beyond their present understanding (Lindfors, 1999). A mode of talk often used in classroom communities of inquiry is *exploratory talk*. Researchers such as Barnes (2008) and Mercer and Dawes (2008) have noted that exploratory talk is frequently observed in small groups of students who work collaboratively on tasks they find purposeful and challenging. The turn-taking function of exploratory talk allows participants to construct knowledge through collective thinking and problem-solving (Mercer, 2002).

Classroom communities of inquiry retain the characteristics of the apprenticeship model of learning and teaching (Mercer, 2002; Wells, 1994). Engagements are often carried out through units of study that are related to real-world problems, student interest, and linked in some way to mandated curriculum or state standards. Students usually work in collaborative groups, addressing questions on topics they find relevant. As Wells (1994) states, "under these conditions, ways can be found to create authentic learning opportunities that meet the criteria discussed above" (p. 15) such as real world problems, student interest, and mandated standards. An important feature of classroom communities of inquiry is that activities are based on a pedagogy of inquiry. The stance towards inquiry leads to instruction that is responsive to the demands of students and the particular context in which learning takes place. The responsiveness allows for units of study to be shaped by the learners within that community, so that learners have a better understanding of the discipline involved, as well as the semiotic tools used to construct knowledge (Wells, 1994).

Another distinguishing feature of classroom communities of inquiry, a feature different from communities of practice, is reflection (Wells, 1999). Mills (2014) states that reflection is what holds all the other processes of inquiry together by helping us "move forward by looking back" (p. 79). Knowledge construction happens as learners reflect on first-hand experiences with the guidance of their teacher or other learners. Learners engage in dialogue, making connections between what is known and what is being learned, through the different objects and artifacts being created.

What classroom communities of inquiry may look and sound like. According to Vygotskian beliefs, education is about creating a particular environment, no matter the diversity of their background, as students and teacher collaboratively engage in purposeful and genuine learning activities. As students participate in these activities they gain the knowledge, skills, strategies, and values that are particular to that culture so they may be able to participate in the activities of the larger community outside the school walls. Teachers apprentice students into constructing knowledge. During this process students develop the temperament to "act creatively, responsibly and reflectively in achieving their own potential and constructing a personal identity" (Wells, 1999, p. 335).

To achieve Vygotskian beliefs about education, a classroom community of inquiry holds the greatest potential. Wells (1999) believes the following characteristics help classroom communities of inquiry achieve these goals:

- A classroom community of inquiry is committed to collaboratively constructing knowledge, mainly through talk.
- Curriculum is organized around themes or units of study based on inquiry, which nudge children to wonder, ask questions, and work together in the construction of knowledge.
- Classroom goals should be negotiated with students. These goals must:
    - help students develop their concerns and passions, and remain open-ended to allow multiple perspectives;
    - involve the whole child which includes emotions, curiosities, and personal and cultural values;
    - create various opportunities to learn the tools of a particular culture in a purposeful manner;
    - encourage group, collaborative work, and individual effort;
    - honor multiple ways students come to understand and the related products used to demonstrate their understanding.
- Teachers must ensure opportunities for students to:
    - use multiple modes of representation as a tool for group and individual understanding;
    - share their work with others and receive constructive feedback;
    - reflect on their work as an individual and whole group;
    - receive guidance within student's zone of proximal development.

Conclusion

I believe when a sociocultural framework exists within an inquiry as a philosophical stance, Vygotskian views of education are supported through the creation of a classroom community of inquiry. Within this type of classroom, I believe knowledge is constructed as a community when teacher and students move in and out of the role of apprentice as they wonder, question, and collaborate alongside each other.

However, I felt my practices did not always live up to my beliefs. I knew the right kinds of things to say, but my classroom practices did not always meet the expectations of my beliefs. I understood this and for a while, felt helpless that I was not linking my practice with my beliefs. All this changed when I participated in the Oregon experience, and I had the opportunity to experience inquiry from the point of view of a learner. Therefore, for this study, through qualitative research methods within a teacher research model, I wanted to better understand the Oregon learning experience. By understanding what made the Oregon experience inspirational and meaningful, I wanted to create approximate conditions in my classroom in the hope of better aligning my beliefs with my practice.

CHAPTER 3

Methodology

Through the use of qualitative research methods (Marshall & Rossman, 2006) within a teacher research model (Cochran-Smith & Lytle, 1993; Herr & Anderson, 2005; Hubbard & Power, 2012; Patterson & Shannon, 1993), this study developed over two phases. In *Phase One*, I attempted to uncover features of the community of practice experience in Oregon while working alongside marine biologists engaged in authentic data collection. I captured learning and participation through observation, field notes, photographs, audio recordings, and video recording during the Oregon experience. In *Phase Two*, I deliberately implemented the lessons learned and features observed in Oregon in my own classroom to help my students construct knowledge. Observation and field notes, in the midst and after the fact, helped to capture knowledge construction in the classroom context. Photographs and video recordings were also used for data analysis and classroom decisions making. Having these data from both contexts allowed me to hypothesize and make connections between the two contexts. I was able to notice and name (Johnston, 2004) features of learning in one context, which facilitated classroom decision-making that supported students to take active and reflective roles in the construction of knowledge through an inquiry stance in my classroom.

This study aimed to answer the following questions:

- What features of the apprenticeship experience in Oregon nurtured inquiry and new understandings? How can these features influence classroom decisions?
- How was knowledge constructed in Oregon?
- How does my understanding of knowledge construction influence future classroom decisions?
- How was knowledge constructed in my classroom after deliberately transferring and transforming insights from the Oregon experience?

My study took place in two phases:

- *Phase One* of this study took place in Oregon apprenticing alongside marine biologists collecting authentic data for climate change research;
- *Phase Two* took place within the context of my 4^{th} grade classroom.

For clarity, I will discuss each phase in its entirety, to help the reader focus on the methodology for each phase independently. For instance, I will first discuss the methodology involved in *Phase One* (Oregon context) then discuss the methodology for *Phase Two* (classroom context).

Marshall and Rossman (2006) state all human action is affected by the setting thus, all human behavior should be observed within real-world situations. Human action was observed in two authentic settings that I describe as *Phase One* and *Phase Two*. The two settings proved to be an invaluable part of the research since it allowed me to observe learning in one setting (Oregon), then intentionally create parallel structures that influenced classroom decision-making in the second setting.

As a teacher, removing myself from the context of the classroom to observe learning during the Oregon experience allowed me to position myself as a learner. As

Lave and Wenger (1991) state “changing locations and perspectives” (p. 36) is crucial to the development of the learner. This stance allowed me to fully and completely position myself as a learner, participate as a learner, and identify myself as a learner.

During *Phase One*, I embraced a methodological perspective that defined research as “systematic self-critical inquiry” (Stenhouse, 1981, p. 103). Stenhouse (1981) states that by positioning oneself as inquirer, the researcher is opened to curiosity and a desire for understanding. Important to this view is that the researcher is persistent and patient in the hunt for answers.

As a classroom teacher, it was important to look towards a definition of research that embraced the idea of *systematic self-critical inquiry* by classroom teachers to frame *Phase Two*. Building on Stenhouse, Cochran-Smith and Lytle (1993) define research carried out by teachers as *teacher research*. Teacher research is defined as “systematic, intentional inquiry by teachers” (Cochran-Smith & Lytle, 1993, p. 5) – a definition that parallels my personal and professional beliefs about teaching and learning.

Phase One: Oregon Context

Setting. The Oregon coast provided the setting for *Phase One*. My research was gathered in two places: the intertidal zone and home base. Our work with marine organisms took place in the intertidal zone. When we completed our work, the team stayed in two houses, located several blocks away from each other in the coastal town of Waldport, located two hours southwest of Portland, Oregon.

Home base. The house was laid out in an open-room concept in which the kitchen, dining room, and living room created one large living space. The living area provided a space to share, to laugh, and to build identity as a cohesive group through talk.

The dining area contained a large dining room. Since the dining room table was located between the kitchen and living room, it became the hub of activity. Team members who positioned themselves at the table could easily talk with members in the living room or with those in the kitchen. The large dining room table provided a place for team members to share and debrief after visiting the intertidal zone.

Opportunities to share a meal became an opportunity to bond and create camaraderie. Various team members volunteered to create the menu and prepare meals. The kitchen provided another area in which community was fostered since it allowed individuals to talk and share while preparing meals. It was not uncommon for laughing to be heard from the kitchen, blending with laughing in the other rooms.

The living room area contained comfortable couches and chairs. A small table provided a place to eat and drink. Team members would gather in this area to talk, share ideas, read, or watch television.

Intertidal zone. Team members traveled to two locations along the Oregon coast. One area known as Strawberry Hill, is located about forty-five minutes south of Waldport, OR. To reach this location, team members drove in several rented vehicles. The top of Strawberry Hill contained an area of bushes and trees, several parking spots, and a small, grassy area with picnic tables. On one side of the grassy area was a trail that gradually led down to the beach.

Once on the beach, it is noticeable that the beach is divided in two areas (see Figure 3.1). At one end of the beach is a steep cliff that drops towards the beach. Broken trees and lush vegetation dot the top of the cliffs, while water seeps from the porous side of the cliff face.

Figure 3.1. Beach is divided into two areas.

Halfway down the beach, between the cliffs and ocean, rock created by ancient volcanic activity, is more pronounced. This is the beginning of the upper and mid-intertidal zone – the area of beach that is only covered by water during extreme high tide. The rock is porous and smooth due to the effects of weathering and the ocean tides. The rocks have a few California mussels attached. In the midst of the rock you will find an occasional tide pool. Closer to the water, in the low intertidal zone, there is less sand and more rock. This area is exposed to the air only at the lowest tides. Much of this rock is large and higher above sea level. The tide pools in this area are much larger and deeper (see Figure 3.2). Mussels continue to be bountiful along these rocks. Pisasters dot this area in a-variety of colors.

Figure 3.2. Organisms found in the low intertidal zone.

Participants. Participants during the Oregon context consisted of eight teachers from the Center for Inquiry apprenticing alongside four marine biologists from the University of South Carolina. Our goal was to gain a better understanding of climate change by studying and conducting research on pisasters and mussels in the Oregon intertidal zone. The four scientists regularly conduct climate change research in the intertidal zone in Oregon. As a part of their educational outreach to schools, researchers from the University of South Carolina attempt to bring teachers out into the field when possible. Pseudonyms will be used to respect the privacy and confidentiality of the Center for Inquiry and University of South Carolina participants. A copy of the consent form for participants can be found in Appendix A.

Participants: Center for Inquiry. Participating in the Oregon experience are eight elementary school teachers from the Center for Inquiry. Five teachers are female and three teachers are male. All eight teachers represent grades kindergarten through fifth-grade. Seven of the teachers are White and one teacher is Black. Teachers in this group vary in classroom experience. The most experienced teacher had over twenty-five years of classroom experience; the youngest member had four years of classroom experience.

Participants: University of South Carolina Scientists**.** Four marine biologists from the University of South Carolina led the trip to Oregon. Dr. Brian Helmuth was in charge of the trip and designed the research experiences. The three other scientists were current or former students of Dr. Helmuth.

Data collection methods. Hubbard and Power (2003) compare data collection to that of a carpenter with an empty toolbox or an artist in a bare studio – to do their jobs they need a repertoire of tools and palettes in order to create. For the researcher, the same comparison applies. Since I acted as a participant during *Phase One*, I needed to rely on data collection methods that would allow me to quickly document *in the midst* and analyze *after the fact.* During the first phase in Oregon, data collection methods included observations and field notes, photography, audiotape, and video.

Observations and field notes. While apprenticing alongside Dr. Helmuth and his colleagues was exhilarating, it was hard work and time consuming, often not allowing for time to get away and record data. For example, on the second day in Oregon, I realized I was having difficulty following the timeline I set forth:

> *Well, we've been out for two and half hours and, and I'm not quite following my methodology, say that I will every hour go and take 5 minutes to head out and make some voice memos of what's taking place, what's taking place in the field,*

> *um, so I'm going to have to revise that aspect of my methodology …* (Field Notes 6/6/12 – lines 1-4)

Yet, this honesty and lack of censorship in my notes led me to an important finding about apprenticing and investment alongside Dr. Helmuth:

> *I think one of the reasons why I'm having a hard time getting out here, you know, um, when you're out there in the midst of, of doing this research, let's not even say research or scientific research, um, but when you start becoming engulfed in what you're doing, um, you really do lost track of all time and even the purpose of what you're doing because you're so invested in what you're doing and I think that's what's kind of amazing about this experience more than anything else is, is the level of investment that is being displayed by everyone, everyone here is truly engulfed in what they're doing, um so that time, time is irrelevant …* (Field Notes 6/6/12 – lines 4-12)

Observations and headnotes (Hubbard & Power, 2012) became an important data collection tool since recording raw notes was not always feasible. The use of headnotes allowed me to observe and reflect on critical incidents (Neuman & Roskos, 1997) taking place in the field. Knowing headnotes must get recorded quickly, I recorded them in my field notes and/or through audiotape. Upon returning to our home base, I reviewed my field notes and/or transcribed the audiotape of my headnotes. All field notes were typed so they could be used for analysis.

Reviewing field notes. My notes were reviewed on an on-going basis in order to notice patterns in my note taking process. I first noticed the use of *thick description* (Geertz, 1973) while in Oregon was extremely difficult because it pulled me away from the community that was being formed and isolated me from completely participating with the group. Field notes and headnotes contained brief moments of observations when I quickly described participant's activities. For example, I quickly describe Dr. Helmuth working with Tim and me on the use of the gigapan:

> *Tim and I were kind of standing around him and he was, um, demonstrating how to use the settings, showing us kind of a little more in detail about, you know, what kinds of settings you need on the camera, what settings you need actually on the gigapan, the gigapan set up and some things that he's learned over the last year since he received, since he got the gigapan telling us some of the things he learned by taking gigapan shots and the, the things that were, the changes he has made, the corrections that he's made with some of the, and as we were sitting talking, you know, we noticed a few of the changes that could possibly made…*(Field Notes 6/5/12 – lines 14-21)

Since I was attempting to uncover features of the apprenticeship experience in Oregon, my personal reflection on learning was important to document. I found myself constantly connecting learning in the field to theory. As an example, as I recorded my own metacognitive reflection of working in groups, I caught myself making connections to Judith Lindfors (1999):

> *Um, so reflection really is inquiry as well because it's social, it's also personal, we get feedback from others, share ideas, thoughts, confirm our ideas, disconfirm my ideas, like Lindfors states we're making a change by sharing our thoughts aloud, um we are putting ourselves out there and letting others help us move*

further in our understanding and our knowledge…(Field Notes 6/6/12 part 3 – lines 97-102)

Photography. Photography in Oregon became an important data collection tool because it quickly captured moments I could not capture in my field notes. Participants shared their photos so that I could observe the same phenomena from different perspectives. I was able to use photography to quickly capture participants engaging in work alongside Dr. Helmuth and his colleagues. Instead of relying on the use of *thick description* in my notes, a picture is often worth *a thousand words*. The use of my smartphone became a quick and convenient method of taking high quality, high-resolution pictures that easily synced with my desktop computer for data analysis.

At the end of the day, I reviewed my photographs and downloaded them onto my laptop computer. As I reviewed each photo, I noted where the pictures were taken and gave each photo a title so I could remember what that photo was attempting to capture. Descriptions of each photo were written in the annotation feature of my qualitative research software.

Audiotape. While I did not utilize audiotape as often as photography, it became a quick and easy method of recording headnotes when in the field. When we had a break, or there was a lull in the engagements, I walked away from our group and recorded my thoughts using my smartphone.

Each night, Dr. Helmuth and the teachers from the Center for Inquiry would debrief about the day’s events. When meeting, discussions were audiotaped. These voice memos would later be transcribed when we returned to our home base and when I returned home to South Carolina. Upon being transcribed, I looked for patterns that fit emerging themes and codes using computer software.

Video. Since thick description of notes in the field and back at home base proved difficult, video was important. I used my smartphone and a handheld digital video camera. The smartphone was used to capture spontaneous moments when participants were engaged in various tasks, while the handheld digital camera was used to record a variety of planned demonstrations carried out by Dr. Helmuth and his colleagues. Video allowed me to capture the words and actions of participants in the midst of their participation. Participants also shared their video so that I could observe the same phenomena from a different perspective. I reviewed my video footage and noted when and where the video was taken. A title for each video was given and noted in my field journal.

Organization of data. Data from Oregon was organized in two manners: field journal and typed field notes. The field journal was divided into sections that included personal reflections of my time in Oregon, notes from our whole group discussions, possible codes that could be used during data analysis, possible curricular implications based on readings, voice memo notes, and descriptions of my photos and videos. The field journal acted as a place for my thoughts when I was away from my computer. Personal reflections and other anecdotal notes were typed and organized using a journaling program called MacJournal (Mariner Software, 2012).

Transcriptions: All field notes from Oregon were transcribed, sorted into a folder labeled *Phase One (Oregon Data)*, organized by the type of data collected (e.g., discussions, field memos, pictures, transcriptions), labeled by day (e.g., 6/5/12), and stored on my personal computer. While all field notes were transcribed for later analysis, group discussions were revisited so that critical incidents could be gleaned, transcribed, and analyzed.

Two types of data were transcribed: field notes and audio recordings. My field notes were typed from my handwritten notes. Audio recordings were also transcribed. While recorded headnotes were transcribed word for word, only the critical incidents from group discussions where transcribed. Each transcription included a title, date, and line numbers to efficiently access information.

Photographs, audio, and video recordings: All photographs, audio recordings, and video recordings were synced to my computer. Because of the large amount of photos and video recordings, titles were given only to photos and videos I intended to use for data analysis. All other photos and video kept their generic names (e.g., IMG_0139.jpg or IMG_1587. MOV). Once photos and video were used, they were moved to another folder that included all data source files. This procedure made it possible for coding software to retrieve data.

Data Analysis. Reflection has the potential to act as a catalyst for learning. In fact, Boud (2001) describes reflection "as a process of turning experience into learning" (p. 10). Reflection helped me evaluate those experiences and question my beliefs and practices. As a result, new meanings and knowledge were generated. The process of data analysis was my opportunity to reflect on what I learned in Oregon. Inquiring into my own learning through reflection allowed me to re-engage with those experiences in my attempt to make sense of what occurred in Oregon.

To guide my process of data analysis and provide a level of reassurance, I followed three modes of analysis as outlined by Wolcott (1994). These three modes of analysis are description, analysis, and interpretation. During the descriptive phase, Wolcott believes the researcher needs to "stay close to the data as originally recorded" so that the data "speaks for themselves" (p. 10). This insures that the data is treated as fact (Wolcott, 1994). As a part of the analysis phase, Wolcott believes the data should go beyond description and move towards identifying "key factors and relationships" (p. 10). During the interpretation phase, Wolcott feels that the goal is to "make sense of what goes on, to reach out for understanding or explanation" and to explain, "with the degree of certainty usually associated with analysis" (p. 10-11).

During the first phase, it became difficult to analyze data as I collected it. My participation in group engagements and communal activities was more important than isolating myself from the group. I felt that isolating myself separated me from making connections between what was learned and the context from which learning took place. Not participating would prevent me from fully embracing the experience as a learner. While data analysis is often encouraged as it is collected, I understood that data collection was taking place during a weeklong period, so I became more interested in collecting volumes of data that would be later organized and analyzed once I returned home.

Description. I agree with Lester (1999) when he states that qualitative research often generates a large quantity of notes, recordings, and work samples, all of which needs to be analyzed. Since data does not always fall into neatly organized categories, some method needed to be used to first organize and describe the immense information. I first read through all my data (e.g., field notes, photographs, audio and video recordings) to get a feel of possible critical incidents and themes. Considering Lester's (1999) recommendations for initial organizing of this data, I made notes of these possible critical incidents and themes on large, sticky notes that I posted around my office for constant revisiting. In Wolcott's (1994) words, this helps the researcher single "out some things as worthy of note and relegates others to the background" (p. 13). This information served as initial categories for later coding and data analysis. As an example, some of the initial themes I noticed revolved around the following:

- Community activity
- Immersion
- Purpose
- Pay attention
- Repeated opportunities
- Take initiative
- Talk
- Intense Concentration (Field Journal - Possible Codes - 7/31/12)

As I looked at these initial categories, I attempted to describe and define these categories in order to provide an initial lens from which I would analyze and code my data.

Analysis. Since qualitative designs often include the researcher as a tool in their research, Wolcott (1994) believes that analysis is important because it allows the researcher to wrestle the data from its origins and transform it into mutually agreed upon knowledge. To aid in this process, the constant comparative method of qualitative data analysis (Glaser, 1965; Lincoln & Guba, 1985) was used to generate theory grounded in the data. I used a computer program called HyperRESEARCH (ResearchWare, 2014) to help me analyze the data. All data, including transcribed notes, photographs, video recordings, and audiotape, were imported into the program to be coded and analyzed for patterns. The data from this research was read and constantly revisited. I annotated each code to include reasons for coding a particular piece of a data. For example, as I was coding a particular picture, I noticed that three teachers from the Center for Inquiry were working closely together collecting data and sharing what they were learning. Combining a code from the descriptive phase (community activity) with *position as learner*, I noticed teachers often working together in the spirit of inquiring. I began to notice an emerging theme and coded this picture as a *community of inquirers.* According to my annotation for this code

> While the code doesn't seem to get everyone, Tammy, Amanda, and Chris work together as a community of inquirers. Each member of this group have their distinctive jobs yet they collaboratively work together in the spirit of inquiry. They all seek communal knowledge of climate change and they hope their efforts will benefit the larger knowledge base. (HyperRESEARCH – IMG_0137.JPG)

Analysis also included personal reflection. At the end of each coding session, analytic memos (Marshall & Rossman, 2006) were recorded in my journaling software to serve as a record of my thinking concerning emerging theoretical ideas and relationships between categories.

Categories emerged as the data was coded and recoded. These categories were refined as coded incidents and were compared with each other. As theory developed, delimiting features within the constant comparative method began to occur which helped further refine developing theory.

Interpretation. After initially coding the data, I started organizing the data in order to find relationships. These initial codes were placed on sticky notes and manipulated in order to observe related ideas. As an example, I began to notice that community activities begin with some kind of demonstration by the marine biologists from the University of South Carolina. After the initial demonstration, the marine biologists from the University of South Carolina supported the Center for Inquiry teachers through the apprenticeship model of learning (Rogoff, 1990), expecting the teachers to observe and pitch in when appropriate.

It is important to note that the interpretation stage is not a final or concluding stage. The description, analysis, and interpretation during *Phase One* acted as an initial lens from which to view *Phase Two*. By treating *Phase One* as an initial lens from which to view *Phase Two*, I was better able to make connections and notice parallel structures between the two phases.

Timeline. *Phase One* in Oregon lasted approximately one week. The trip began Monday, June 4^{th,} 2012 and ended Sunday, June 10th. All data was collected during this period. I began the analysis process upon returning to South Carolina.

Limitations to *Phase One* of the Study. Participating in the same community I was attempting to study had its limitations. Because I became so invested in the community, it became difficult to collect data in a more organized and systematic way since pulling myself away from the community meant isolating myself from the very group I was trying to identify and participate with. While traditionally researchers analyze data as they collect it in order to observe patterns and to guide additional data collection, this method did not seem feasible and may have limited aspects of the study.

Phase Two: Classroom Context

Entering *Phase Two* pushed me even more to begin identifying myself as a *teacher-researcher* – a stance I knew I would need to undertake yet, apprehensive to embrace. Hubbard and Power (2012) describe this shift brilliantly when they state, "The changes in our teaching lives as we shift toward a teacher-researcher stance contribute to the process of 'dissolving and shaking' our sense of self (p. 241). Despite my initial apprehension with this identity, a teacher-researcher stance was the only methodological stance that made sense for this particular phase.

Cochran-Smith and Lytle (1993) believe that teacher-researchers are positioned within the classroom in a unique manner because they provide a genuinely emic view of the ways students and teacher construct knowledge together. In fact, it is this emic view of the relationship between student and teacher that increases the teacher-researcher's *knowledge-of-practice* (Cochran-Smith & Lytle, 1999). Knowledge-of-practice is a concept that assumes "that the knowledge teachers need to teach well is generated when teachers treat their own classrooms and schools as sites for intentional investigation" (Cochran-Smith & Lytle, 1999, p. 250). This concept also emphasizes that the knowledge teachers gain from their systematic inquiry into their classroom will be used to "solve problems, represent content, and make decisions about the daily world of the classroom" (Cochran-Smith & Lytle, 1999, p. 276).

Context. The second phase of my research took place within my classroom. My classroom is located at the Center for Inquiry, located in the Richland Two School District. The school district is located in a suburban area just outside the city limits of Columbia, South Carolina. The Center for Inquiry is a Richland Two magnet school that serves approximately 250 kindergarten through fifth grade students. The school serves as a partnership school, through its relationship with the school district and the University of South Carolina. One of the unique features of this school is its focus on inquiry-based instruction, which emphasizes students to become active and reflective participants in their learning, as well as an integrated approach to curriculum through inquiry-based methodology.

Participants. The participants consisted of twenty-one students from my 2012-2013 fourth-grade classroom. The class was made up of ten boys and eleven girls from a range of socioeconomic factors ranging from low to high-income families. From this group, eight students were Black, nine students were White, two students were Asian, and two students were racially mixed. A copy of the consent forms for parents and students can be found in Appendix B.

Data Collection Methods. While some data collection methods during *Phase Two* were similar to those in *Phase One*, because of the classroom context, I had to differ in some data collection methods. Key methods used during *Phase Two* included observations and field notes, photography, video, and student work samples.

Observations and field notes. Hubbard and Power (2012) state that the teacher-researchers must be their own important tool. They must be ready to document various phenomena, as it exists, recording the good and the bad. To maintain focus, my observations (Hubbard & Power, 2012) took place during two parts of the day: morning explorations (time of day when students explore those things they are personally interested or passionate about) and a unit of study on climate change. I quickly recorded my field notes on a portable tablet device as I observed students. For example, as students were sharing their thoughts on their understanding of climate change, I captured the following anecdote

> When I talked with students, most students said variants of the same thing - climate change is about temperature and how the temperature changes from day to day and season to season. Some students had never heard of it, some students heard it from the news or weather reports, and some students had heard of it but not sure from where. Peter then talked about climate change but added how global warming leads to climate change. Global warming was a term most students had heard of and could articulate, in some manner, aspects of. This surprised me quite a bit but showed the power of how one's student's words can change the conversation. (Field Notes 1/8/2013 – lines 34 - 42)

Later, these notes were transferred into qualitative research software (HyperRESEARCH) to be analyzed and coded for patterns.

Field notes in the classroom were used to capture my lesson plans, including lessons that spontaneously changed. While I made careful plans, I believe the best teaching takes place when teachers are responsive to the needs of their students. I captured my thinking through field notes, including reasoning for why I changed my lessons. For example, I had planned to build off of some work students were doing the previous week using diagrams. In my journal I recorded the following notes

> So today's lesson was originally going to be:
>
> 1. Doing a Google image search of diagrams revolved around "greenhouse effect" or "greenhouse gases"
> 2. In pairs, I wanted each group to find two images

3. Partners would be able to read and explain those diagrams. Diagrams would be placed into a document and sent to me.
4. Diagrams would be placed on the SmartBoard and partners would have to read and explain those diagrams to the class. (Field Notes 2/12/2013 – lines 9 - 16)

Based on the student's questions it became obvious students had some misconceptions. In fact, "…it became clear that some understood things exactly as I shared, some missed pieces of information I shared, and some had their own interpretations of what I said" (Field Notes – 2/12/2013). As I apprenticed two students into helping them make sense of their diagrams, I came to the following realization

> Helping Beth and Jeena make sense of their diagram made me think that maybe I should have provided an example of what I wanted them to do during this assignment …I went through the same process I asked students to go through. I opened up Google and typed in "greenhouse effect." Next I clicked on "Images." Just like everyone else, a number of various images came up. I clicked on one image and tried to make sense of the diagram in a manner such as a think aloud. I thought aloud how this diagram wasn't helping me make sense and the diagram lacked some information …So I pulled up an image I had already found that made some sense to me and helped me better understand why CO_2 in the atmosphere was so bad. I made it big on the SmartBoard, went up to the board, and started explaining what the diagram meant. (Field Notes 2/12/2013 – lines 87 - 100)

My use of observations and field notes went beyond what I noticed in class. They were used to record my thinking in order to impact future classroom decisions. For example, during explorations, two students disassembled an old DVD player and created a presentation on what they uncovered. After their presentation I recorded my thoughts

> Hannah and Marissa's presentation demonstrates to me the possibilities and potential of explorations. Even the boys' presentation on Legos was great with their innovative use of the Chromebook camera, taking pictures of their Lego creations and put them in their presentations. They were much more in depth into their presentation then before. Today's explorations presentations seem like a new turning point in our explorations reminding me of the possibilities of this time. Every day may not be a better day than before but over time, students are showing, in an authentic manner, their inclination to explore and investigate. (Field Notes 2/27/2013 – lines 43 - 50)

Video. While field notes were used to record lesson plans and my daily reflections, video was the primary means for collecting data during *Phase Two*. Video was used to collect "visual representations of the daily life of the group under the study" (Marshall & Rossman, 2006, p. 121). Marshall and Rossman (2006) feel that taking video has the unique ability to capture phenomena in an objective manner yet, always from the point of view of the researcher just as with other forms of data collection. Video proved invaluable because it allowed me to record phenomena as it occurred, then analyze it at a later point. With video I could revisit the data indefinitely, analyzing it through multiple perspectives as I gained new knowledge and information. Classroom phenomena were recorded from two perspectives: whole class and small group/individual.

Whole class video. There were a number of occasions when whole class instruction occurred during the unit of study. A digital video camera was set up in a corner of the classroom to capture this phenomenon. I attempted to capture a majority of whole class discussions and whole class demonstrations.

Small group/individual video. When students gathered in small groups or worked as individuals, I captured this phenomena using a smartphone. I attempted to capture a majority of individual and small group work. This allowed me to capture my interactions with students as they worked. The ease of use of the smartphone allowed me to capture talk and student work while the size of the smartphone allowed me to get close to students in an unobtrusive manner. I found that students were used to being recorded on small devices such as a smartphone and seemed less intimidated while being recorded.

Photography. While video proved invaluable for recording the daily life of the classroom, photography proved to be an important part of capturing student work. As I interacted with students I snapped photos of their classroom work in progress or when their work was completed. Having a photo of student work, instead of the actual work, allowed me to use this work as data, to be imported into qualitative research software to be analyzed and coded. As an example, students created diagrams of their understanding of global warming (see Figure 3.3).

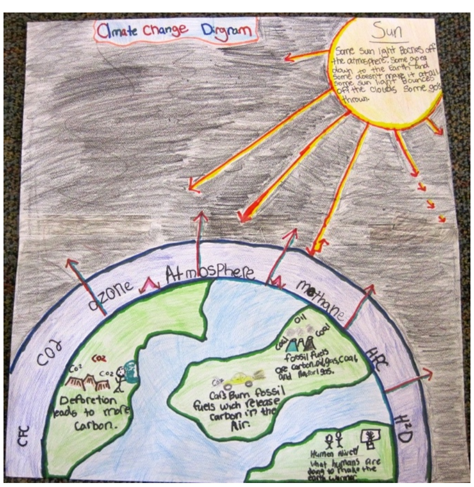

Figure 3.3. Photo documenting student diagram.

Photography allowed me to capture classroom thinking. When engaging in classroom discussions, I often recorded our thinking on a whiteboard. At the conclusion of the discussion, I would take a photo of the whiteboard to document the conversation (Figure 3.4). Having a photo of our discussion allowed me to import this data into qualitative research software to be analyzed and coded.

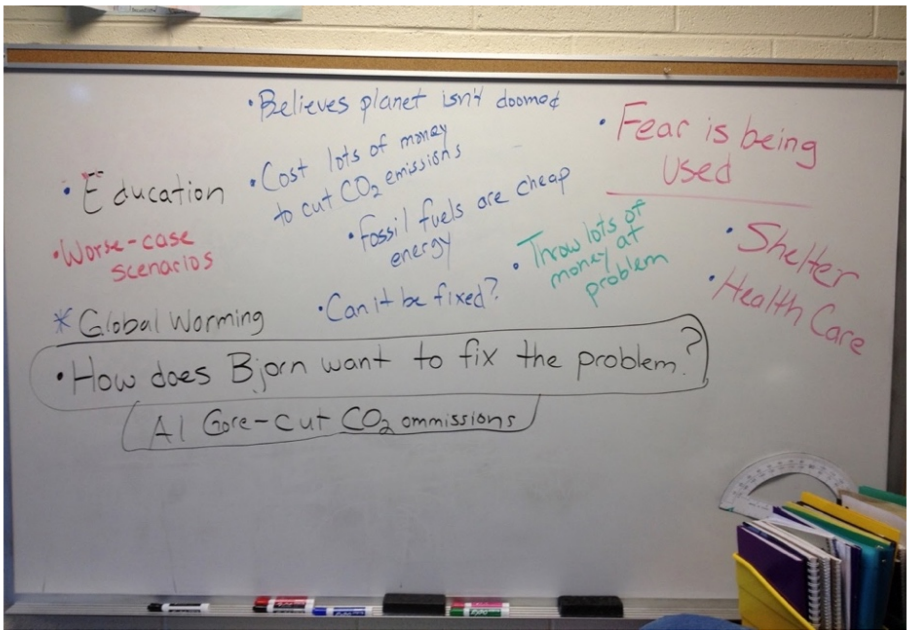

Figure 3.4. Photo documenting classroom discussion.

Organization of Data Analysis. My desktop computer became a hub for storing and organizing the amount of data that was collected and analyzed during *Phase Two*. Classroom observations and field notes were recorded using an app called MacJournal (Mariner Software, 2012). Field notes were given a title, dated, and synced with my desktop computer so I had a list of entries organized by date. The MacJournal app allowed me to create multiple folders so I could separate field notes and analytic memos. Having my field notes and analytic memos typed allowed for easier retrieval of data through key words and importation into qualitative research software.

All photographs and videos were reviewed and imported into qualitative research software. Those that were coded were given a title and organized into separate folders. For instance, photographs and video were organized based on the curricular structure they were collected from (e.g., during our unit of study on climate change or explorations).

I pulled out critical incidents (Newman, 1998) to be transcribed as video and audiotape were analyzed. Transcriptions were typed, titled, and dated. I used the line numbers feature in the word processing program to make retrieving and analyzing data easier. Typed transcriptions were imported into qualitative data software to be analyzed and coded.

Data analysis. Hubbard and Power (2012) state that teacher-research projects often end in defeat as they attempt to analyze their data. They liken this process to "funneling mashed potatoes through a straw" due to the enormity and muddiness of this process (Hubbard & Power, 2012, p. 117). As a teacher-researcher new to this process, I had to work through my insecurities and uncertainties, coming to understand that there is no *one-way* to analyze data.

During *Phase Two* I continued to follow Wolcott's (1994) three modes of data analysis. These three modes of data analysis are description, analysis, and interpretation.

Description. I immediately began singling out items of worth and relegating other items into the background just as Wolcott (1994) suggested. For example, as I made classroom decisions based on findings from *Phase One*, I observed similarities between the two phases. Just as the participants in *Phase One* engaged in community learning activities, participants in *Phase Two* undertook similar learning engagements as a community.

Constant revisiting of the data helped me to look at my data in new ways, especially as I read professional literature and conducted member checking. This input provided various perspectives on the data that allowed me to see new connections. The combination of revisiting data along with professional reading allowed me to describe data in more sophisticated ways. Not only did this affect *Phase Two* data, but also it caused me to go back and revisit *Phase One* data to describe it in new ways. For instance, when students attempted to solve a problem or to find answers to an information-seeking question, students uncovered a variety of information in the process of finding answers. As they sifted through this information I came to realize just how much my students were constructing their own knowledge. This pushed me to go back to my *Phase One* data to observe how participants were constructing knowledge in the Oregon context.

Analysis. I used the constant comparative method of qualitative data analysis to interpret the data (Glaser, 1965; Lincoln & Guba, 1985). I continued to use a qualitative data analysis computer program called HyperRESEARCH (ResearchWare, 2014) to help me analyze the data. Photographs, video recordings, transcribed notes, and audiotape were imported into the qualitative data analysis program to be analyzed for patterns and connections across phases.

During this second phase, I did not impose *Phase One* categories but rather, built upon the codes that were generated. I used what I learned in *Phase One* to create the conditions to grow a community of practice in my classroom. *Phase Two* patterns emerged when data from *Phase One* and *Phase Two* were compared using the constant comparative method. As an example, I noticed that in both phases, participants worked together, collaborating towards a common goal. They used their individual understanding, the knowledge gained from their inquiring, and the knowledge gained from collaborating, to construct new knowledge. I originally coded each example of these particular phenomena as *community activity* and *generating knowledge*. As I revisited the data, I came to realize these two codes were leading me in another direction – that knowledge was constructed in community. I began to wonder if I had other examples that were twice coded. This is when I revisited my data in a whole new light. I noticed that particular photos and video were coded using similar codes. When analyzing a video clip titled "*Sharing Greenhouse Gases.m4v," this clip contained codes such as *community generated knowledge, speak from the heart,* and *observing and pitching in.* As I noticed similar codes in data I had previously coded, I looked at new data through a more focused lens. Through continued encouragement via member checking, I revisited *Phase One* data to find possible links with my *Phase Two* findings.

Interpretation. Once I noticed larger domains taking place, these domains linked to the professional literature. Spradley (1980) refers to this as *theoretical linking*. Spradley (1980) states when the researcher has linked a particular phenomenon to the literature, this helps the researcher focus their research. As an example, this focus pushed me to look more closely at the ways my students were constructing knowledge. Upon noticing various ways students were constructing knowledge, I organized this information into a chart (see Appendix C). This chart created a place for me to pull what was being theoretically linked across phases. Included in this chart was a critical incident of each category so I could look for patterns across critical incidents. Of even greater importance, was the ability to reflect on these critical incidents and document how my understanding of these categories led to classroom decision making.

I created diagrams to help me interpret the data and help me make sense of my professional readings. Creating diagrams forced me to reflect on how I was theoretically linking what I was observing with what I was reading. I quickly discovered that utilizing diagrams helped in two ways: 1) I was able to see connections between what was being observed and the literature in a manner that was meaningful to me, and 2) dismiss connections between the literature and data I was trying to force.

Timeline. Classroom data was collected between January 2013 and May 2013. Data was collected twice a week - Tuesday and Thursday. These two days were set aside for engaging in my unit of study on climate change. The climate change study lasted between ninety minutes and two hours. Three weeks in April, data was not collected to allow my final student teacher to complete her two-week final teaching assignment. At the conclusion of her two weeks, students were on Spring Break. While some data was analyzed in the midst, after completing my data collection, I immediately jumped into analyzing the remainder of my data. Analyzing data took place between May 2013 and May 2014.

Limitations to *Phase Two* of the Study. I understand my position as teacher-researcher may have hindered the type of data collected and the time needed to adequately collect data. I came to understand that collecting classroom data could be challenging because the primary role of the teacher-researcher is that of teacher. While the teacher-researcher is cognizant of collecting data that is substantial and meaningful, they must always be aware that collecting data comes second to making sure the teacher-researcher is meeting the needs of their students. This often means data collection takes a back seat.

At the same time, teacher research nudges teachers to improve their teaching practices and enrich their teacher knowledge. Hubbard and Power (2012) believe that "teacher research is a natural extension of good teaching" because teacher research "involves the kinds of skills and classroom activities that already are a part of the classroom environment" (p. 3). As a classroom teacher whose personal and professional perspective of learning is viewed through an inquiry-based lens, inquiring into my own practices is a natural extension of who I am.

Across Phases

Trustworthiness. To help establish trustworthiness across both phases, I relied on the use of triangulation, member checking, and peer debriefing.

Triangulation. Triangulation refers to the use of multiple sources and data collection sources to gain deeper insight and confirm findings (Hubbard & Power, 2012; Lincoln & Guba, 1985). By combining the use of observation and field notes, photography, audiotape, and video, I attempted to uncover features of learning that took place during *Phase One* of my research in Oregon. This information later provided a basis for my work in *Phase Two*. During the second phase, I continued the same methods of triangulation.

Member checking. Member checking refers to the sharing of data with individuals who acted as stakeholders in the original collection of data (Lincoln & Guba, 1985). Since I worked alongside most participants in *Phase One*, I engaged in some formal, but mostly informal, member checking at the Center for Inquiry. Member checking proved invaluable when I needed more information about a particular task. As categories developed, I discussed initial findings with participants who provided further feedback. For instance, when I discussed some initial themes with Chris Hass, revolving around purpose and investment, he suggested that I look further into my data to see if *choice* was evident.

Negative case analysis. Negative case analysis looks at a particular phenomenon and attempts to analyze why the outcome did not go as planned or anticipated (Lincoln & Guba, 1985; Shenton, 2004). Since the classroom is an environment of unexpected happenings, I believed that it was important to analyze incidents that did not go as planned. For example, as I recorded on video two students sharing a diagram, it sounded like they did not understand a particular diagram. As I questioned them, they lacked understanding of their diagram. They kept pushing the other to share instead of taking the initiative to understand the diagram. They read directly from their presentation instead of speaking from the heart. Negative case analysis strengthened my understanding of the importance of speaking from the heart as a means of taking initiative to demonstrating one's knowledge.

Peer debriefing. Peer debriefing often refers to the process of sharing research findings with individuals who may not be stakeholders in the project (Hail, Hurst, & Camp, 2011). There were many occasions in which I engaged in conversations with parents and teachers outside the Center for Inquiry that revolved around my data analysis and findings. Hail et al. (2011) describes that teachers who share their findings with others "may recall additional facts that had not been considered prior to sharing. This in-depth review often shifts the emotional slant to a more objective perspective as the 'facts' are presented" (p. 75). As I shared my findings, it was important that I find the words and phrases to help others understand my work so that I could better understand my own work.

Prolonged engagement. This study was largely dependent upon prolonged engagement and persistent observation during both phases. As an inquirer and classroom teacher, I have the opportunity to go beyond collecting snapshots of learning and tell a complete story of inquiry in action. These stories are often not continuous and can take place over the course of several days, weeks, or months. Reflecting on learning as it happens, implementing these practices, and observing how these changes affect learning takes time. I am investing the time needed through prolonged engagement to reflect, implement, test current hypotheses, and make refinements in my procedures.

A story is more engaging when there are illustrations that accompany it. Prolonged engagement and persistent observation in both settings provided an opportunity to illustrate this story of inquiry in action. Illustrations of patterns come from critical incidents I identified as a result of the constant comparative method. As a result, I named the pattern, defined the pattern, and provided examples of the pattern in the following chapters.

Human Subjects Approval. This study was approved by the University of South Carolina's Internal Review Board (IRB), Richland Two School District, and the Center for Inquiry. During *Phase One*, teachers from the Center for Inquiry and University of South Carolina participants signed letters of informed consent. During *Phase Two*, parents and students assigned letters of informed consent. Letters of informed consent consisted of an introduction to the study, a purpose of the study, description of study procedures, a summary of risks and benefits of participation, a confidentiality statement, an explanation of voluntary participation, and contact information. Since students were direct subjects of the study, they appeared in audio transcriptions and video. Therefore, parents of students received letters of informed consent that included a description of the study, the student's role, the option to not participate, and contact information.

Subjectivity. I believe my knowledge of inquiry-based methodology can be considered a possible limitation to the entire study. Inquiry as an epistemology of learning is deeply engrained within my personal and professional life. I believe all learning, at home or in the classroom, begins from an inquiry stance of exploration, investigation, collaboration, and questioning. This stance influenced the lens from which I viewed all processes of data collection, analysis, and interpretation.

At the same time, taking on an inquirer stance means gathering as much information as possible in order to reach a conclusion. This stance means I am open to various perspectives, which include anomalies in the data. Since inquiry relies on community, collaboration, and cooperation as important facets to its implementation, *going native* (Lincoln & Guba, 1985) is potentially an issue. To be an inquiry-based classroom teacher means being a part of the accepted classroom culture - to avoid *going native* is impossible. I am aware of these potential biases. To address issues with going native, it was important for me to lay a foundation of my research by developing self-monitoring strategies. Stenhouse (1981) states, "Through self-monitoring the teacher becomes a conscious artist. Through conscious art he is able to use himself as an instrument of his research" (p. 110). Since I understand my role as an instrument in investigating my classroom, reflexivity plays a crucial part of my research. Thus, it was important that the self-monitoring strategies I used nudged me towards greater reflection. While many of these self-monitoring strategies have been discussed within the data collection and analysis, these strategies included indefinite triangulation with students, student intern, doctoral students in research internship, weekly review of field notes through analytic writing, and the use of the constant comparative method. All of these strategies, in one form or another, nudged me towards greater use of reflective knowledge (Berg, 2006) and not simply reporting findings as fact. The following table (Table 3.1) summarizes methodological features found in *Phase One* and *Phase Two*.

Table 3.1

Comparison of methodological features of Phase One and Phase Two

Methodological Features	*Phase One*		*Phase Two*	
Setting	• Oregon Coast ▪ *Intertidal Zone* ▪ *Home base*	o Intertidal zone at Strawberry Hill and Boiler Bay o Home base in Waldport, OR	• Center for Inquiry • Richland Two School District	• My 4th grade classroom
Participants	• Teachers from the Center for Inquiry • Marine biologists from the University of South Carolina	o Eight teachers from grades kindergarten to fifth-grade o Teacher experience ranges from 4 to over 25 years o Four marine biologists led by Dr. Brian Helmuth	• 2012-2013 school year • 21 students	o 10 boys and 11 girls o Socioeconomics ranging from low to high-income o 8 Black students; 9 White students; 2 Asian students; 2 racially mixed students
Data Collection Methods	• Observations and field notes • Headnotes • Photography • Digital audio • Video	o Headnotes to observe and reflect on critical incidents in intertidal zone; recorded in field notes o Photography to quickly capture engagements and demonstrations in intertidal zone o Digital audio quickly records headnotes from intertidal zone and home base debriefings o Video captures spontaneous participant engagements and demonstrations in the intertidal zone	• Observations and field notes • Video ▪ *Whole class video* ▪ *Small group/individual video* • Photography	o Observations during morning explorations and unit of study o Field notes capture lesson plans and future classroom decisions o Video records phenomena as it occurred ▪ *Digital video camera records whole group engagements* ▪ *Smartphone records small group/individual engagements* o Photography captured student work in progress and when completed; record classroom thinking
Organization of Data	• Field journal • Transcriptions • Photographs • Digital audio • Video	o Field journal divided into sections including personal reflections, notes on whole group discussions, codes, etc. o Critical incidents transcribed pertaining to field notes and audio recordings o Photos, audio, and video to be analyzed given titles and included in data source file	• Observations and field notes • Transcriptions • Photographs • Video	o Field notes titled, dated, and organized in MacJournal software o Photos and video to be analyzed given titles and included in data source file o Critical incidents transcribed pertaining to field notes and audio recordings
Data Analysis	• Description • Analysis • Interpretation	o Initial read through data to get a feel of possible critical incidents and themes; attempted to describe and define initial categories to provide lens to analyze data o Constant comparative method to generate theory grounded in data o Organize data to find relationships	• Description • Analysis • Interpretation	o Constant revisiting of data, professional literature, member checking helped see new connections o Constant comparative method to generate theory grounded in data; built upon *Phase One* codes to analyze *Phase Two* data o Theoretical linking connected data to literature o Diagrams helped interpret data
Timeline	• June 4, 2012 – June 10, 2012		• January 2013 – May 2013	

Methodological Features	*Phase One*		*Phase Two*	
Limitations to Phases	• Investment in community	○ Investment in community made data collection less organized and systematic ○ Did not analyze data as collected	• Role of teacher researcher was secondary • Teacher researcher natural role	○ Data collection was secondary to meeting needs of students ○ Inquiring into own practices natural extension of who I am

CHAPTER 4

Learning Through an Apprenticeship Model in the World and in the Classroom

In Jacqueline Kelly's (2009) *The Evolution of Calpurnia Tate,* Calpurnia is musing in her grandfather's laboratory. The numerous items of wonderment amaze her: a footstool made of a camel's saddle, a brass telescope from the War, and rows of dehydrated lizards and insects. As she scans the room, Calpurnia notices a gnarly looking armadillo and wonders why her grandfather, with his treasure trove of trinkets, would hold onto such an ugly creature. After asking her grandfather why he does not purchase a new armadillo, Grandfather shares,

> That's true, I could, but I keep it as a reminder. That was the very first mammal I stuffed myself. I learned by correspondence course, which I advise against. If this path interests you, I suggest you apprentice yourself to a master. There are subtleties to the art that cannot be gleaned from merely reading a pamphlet. (p. 96)

Grandfather understood a thing or two about learning. Learning best takes place in the company of others, and as humans, we use each other to push our thinking and understanding of the world (Lindfors, 1999).

Dr. Helmuth understood the importance of learning in the company of others by using each other to push our thinking of the world. He did this by creating a unique learning experience for teachers at the Center for Inquiry through the creation of a space in which teachers learn alongside other, like-minded individuals under the guidance of scientists who are experts in their field. This unique learning experience can be best described as learning through an apprenticeship experience.

In this next section, I will highlight features of the apprenticeship experience in Oregon, which became an integral part of our learning. I will share examples of each feature followed by how my understanding of these features, consciously influenced classroom decisions. The following features include:

- Community activities
- Position self as a learner
- Learning through demonstrations
- Demonstrating the skillfulness of inquiry
- Knowing-in-action
- Observing and pitching in
- Purpose and investment
- Independence

Features of the Apprenticeship Experience in Oregon

Community activities. When in Oregon, I rarely, if ever, witnessed scientists working alone in isolation of each other. All individuals engaged in activities that were considered community activities. In some way, each person worked alongside, or was communicating their actions with other individuals. When teachers worked toward a common goal, such as pulling tubes from pisasters or using the laser level to measure height, all individuals worked in small groups or in pairs.

Working as a group allowed individuals to collaborate and share new thoughts and ideas. While in these groups, teachers from the Center for Inquiry participated in the various group activities. Each member contributed in some manner towards a common goal. As teachers and scientists worked alongside each other, talk was the primary means of communicating. Talk was used to explain procedures during demonstrations, was used to question and make sense of the task, and used to bond with fellow members of the community.

As an example, in Figure 4.1, a group of teachers and scientists worked alongside each other as they dissected mussels. We were shown how to open the mussel, separate the two halves using a scalpel or razor blade, and dissect the sections that would be used for DNA sampling. An individual could do the dissection of the mussel, though the

Figure 4.1. All tasks in Oregon were structured as community activities.

task would be much more arduous. Instead, Dr. Helmuth organized the activity so that a small group of individuals could work together to dissect the mussels. Included in that group, was Mackenzie, one of Dr. Helmuth's colleagues, who demonstrated the task, answered questions, and provided assistance when needed. When not needed for her experience, she engaged in talk that facilitated the bonding of individuals working together.

How community activities influenced classroom decisions. I came to fully understand the importance of people working alongside each other, especially when working towards a common goal. Historically in my classroom, community activities seemed relegated towards the area of reading and writing, while math, social studies, and science were not considered. For example, students would participate in whole class discussions around a particular read aloud or the sharing of a piece of writing, but I rarely extended this whole class discussion towards concepts in math, social studies, or science. I have come to understand that when several students get together to problem solve, multiple perspectives are at work; students not only learn from the process but each other.

An example of my students engaging in community activities took place during explorations – a curricular structure that emphasizes students inquiring into those things they are interested or passionate about. Students worked together towards a common goal such as building an FM radio out of Snap Circuits or creating a presentation on each state in the United States (see Figure 4.2). As students built they discussed their project while participating in talk that builds community. When students encountered a problem, they collaboratively problem solved until the situation was resolved. More important, when students reflected on their learning, they came to appreciate and value others and their knowledge. For instance, when students were asked to reflect on their learning during explorations, one child mentioned, “I learned that I learn more when I am in a group with other people. I also find good examples from other people.” Another child shared, “I learned that as a learner I can try new things and have fun with it. Also, I've learned that I can use others to help me learn things, but not use them to do the whole thing for me."

Figure 4.2. Students collaboratively worked on a presentation.

Position self as a learner. A feature of the apprenticeship experience in Oregon I came to understand involved all participants and how they positioned themselves as learners. According to Wells (n.d., 1999), when individuals work within an apprenticeship model, there is no designated static teacher or expert. As newcomers and mentors collaborate in an activity, each participates in the activity by assisting the other, learning from each other as they contribute. For example, in Jennings and Mills (2009) five-year ethnographic study, they found that when students took responsibility and action for their own learning, as well as the learning of others in the classroom, students and teacher often switched roles as mentor and newcomer to that particular experience.

In a recent interview, Tim Cook, the CEO of Apple computers, stated, "The best places where people learn, you can't tell the difference between teacher and students. The truth is, we all learn from each other and we teach each other" (Davis, 2014, para. 15). Transitioning to Oregon, in Figure 4.3, teachers and scientists worked alongside each other in various activities. Some members laid transects along the rocks in order to measure the position of pisasters; some members measured the height of the rock using a laser level. No matter the level of experience, it was difficult to tell the difference between newcomers (e.g., CFI teachers) with the least amount of experience and the scientists who possess a greater amount of experience. This is because both teachers

Figure 4.3. Teachers and scientists positioned themselves as learners.

and scientists positioned themselves as learners. Each member of the Oregon team had different expertise to contribute even if the experience was not directly related to knowledge of the intertidal zone. They, in turn, used this knowledge to contribute to the particular activities Dr. Helmuth designed.

Not only did the roles of expert and novice fluidly change as participants in the Oregon experience collaborated in these activities, but also all members came to the experience with a spirit of wonder and inquiry. This spirit allowed participants to position themselves as learners. Thus, this spirit of wonder and inquiry acted as an equalizing force between newcomers and those with more experience since it placed each person in the position as wonderer, inquirer, and learner. As an example, Dr. Helmuth has traveled to the intertidal zone on many occasions. As a scientist, he positioned himself as a learner as a means of inviting new experiences to influence his current knowledge and thinking. When one member of the group discovered at pisaster with seven arms (see Figure 4.4), Dr. Helmuth immediately documented the discovery. He began speculating, along

Figure 4.4. Seven-legged pisaster nudged further questioning.

with those around us, as to why this occurred. These speculations, along with further questioning, helped Dr. Helmuth develop deeper understandings of the marine organisms found in the intertidal zone.

How positioning myself as a learner influenced classroom decisions. When I position myself as a learner, it opens up the possibility to learn from new experiences thus, altering my current knowledge base. I acknowledge that a certain degree of authority has been placed upon myself because of my role as *teacher*. I am expected to carry out this role with a certain degree of expertise. My role as teacher places me in a position in which I am expected to have expertise in various academic areas such as reading, writing, and social studies. Yet, the longer I teach, the more I recognize I need to learn; I learn the most from those I surround myself such as my students.

Traditionally, these positions seem almost contradictory. How can one be a learner and an expert at the same time? An expert is an individual who has vast knowledge in a particular skill or area. But in order to gain this knowledge, experts have to position themselves in a manner that opens them to new knowledge. Experts do not have a stagnant understanding of their field, but a constantly evolving knowledge base that grows with new understanding. Experts are in the midst of learning the skills of their trade as well as learning how to guide newcomers in developing these skills (Rogoff, 1990). Expert and learner are not counterintuitive, but are in fact symbiotic.

In the context of my classroom, positioning myself as a learner meant being open to learning from my students as they developed new understandings of the world. As they constructed new meaning, I learned from *how* they constructed it. During a unit of study on climate change, my classroom was studying how greenhouse gases increase global warming. In the course of learning about global warming, the class kept coming across the term *greenhouse effect*. Students wanted to know what this greenhouse effect was. Using her laptop, Maria did a search on the greenhouse effect and arrived at a website which listed individual greenhouse gases. She immediately pointed to a diagram she found and began explaining Earth's natural greenhouse effect and how this natural greenhouse effect is being altered due to greenhouse gases. Instead of reading through a multitude of websites, sifting through much information, Maria used a diagram to help her make sense of greenhouse gases and the greenhouse effect. To Maria, this was a much more efficient use of her time by helping her construct knowledge in a much more effective manner.

What I immediately came to realize through Maria, is that students when supported, have a propensity to use any means necessary to help them construct knowledge. For Maria, reading diagrams was a much more effective and efficient means of making sense of the greenhouse effect. Positioning myself as a learner nudged me to make instructional decisions that altered how students participated in this unit of study on climate change. I pushed students to find diagrams that would help them make sense of the greenhouse effect or other climate change concepts. I asked students to share their thinking with me through diagrams. Students found diagrams *they* believed would illustrate the greenhouse effect in an effective and efficient manner and they shared these with other students. Later in the unit of study, students created their own diagrams to demonstrate their understanding of the greenhouse effect, global warming, and its causes (see Figure 4.5).

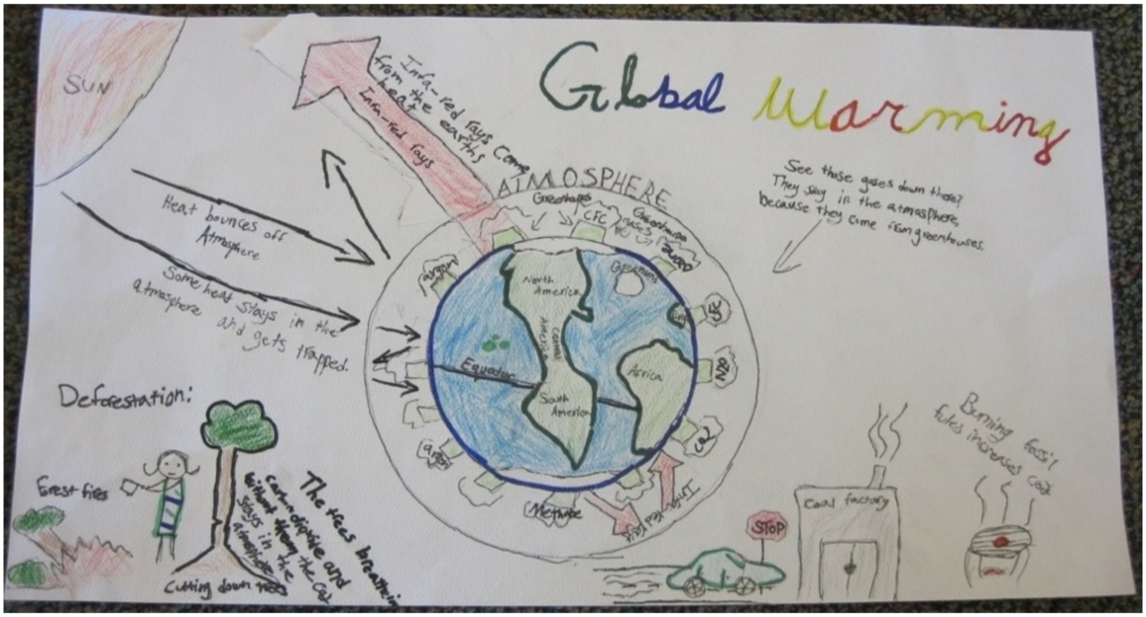

Figure 4.5. Student created diagram of global warming.

Learning through demonstrations. One of the most important aspects of the apprenticeship experience was learning through demonstrations. As Smith (1981) stated, “The first essential component of learning is the opportunity to see how something is done” (p. 108). More experienced members often provide newcomers these demonstrations. They demonstrate the potentials or possibilities of how a particular task might be accomplished.

In Oregon, teachers performed that same tasks scientists participated in with precision. One task we were expected to participate in was the dissection of mussels in order to collect DNA samples, which would be used by one of Dr. Helmuth’s doctoral candidates, to measure the mussels’ stress levels. Sitting on the mussel bed we pulled mussels from, we gathered in a circle around Mackenzie who explained the anatomy of the mussel. Next, Mackenzie demonstrated how to open the shell in a safe manner. Once the mussel was opened (see Figure 4.6), she pointed out the various anatomical parts of the mussel. Mackenzie explained that we would be collecting the ductor, mantle, and gills of the mussel. After she showed us the anatomy of the mussel, she demonstrated how to dissect those parts, explaining in detail how to move one mussel organ to get to another organ.

Figure 4.6. Mackenzie demonstrated how to dissect a mussel.

After Mackenzie demonstrated on a second mussel, we were all invited to try dissecting ourselves. We pulled a mussel and followed Mackenzie's explanation. As we dissected our mussel, Mackenzie remained nearby, providing additional support when needed by answering questions or demonstrating particular steps.

How my understanding of demonstrations influenced classroom decisions. When I came to understand the importance of demonstrations, it forced me to re-envision my role as a classroom teacher. Based on my adult understanding of the world, I made assumptions that students understood a variety of tasks I take for granted on a day-to-day basis such as looking for information on the Internet or reading a map. When making assumptions such as these I did not capitalize on key demonstrations that could potentially further my student's understanding of the world. Providing key demonstrations, grounded within the particular learning context, helps students make better sense of the task and of their world. Demonstrations in Oregon taught us *how to learn*, *what to learn*, and *how to successfully gather and report data*. I learned I needed to transfer this model to my classroom.

I asked students to work in pairs during a lesson on global warming as they conducted an Internet search of diagrams that demonstrated global warming. Each group was charged with a) finding at least two images they believed demonstrated global warming, b) partners would have to read and explain those diagrams to each other and myself, and c) diagrams would be placed on the Smart Board and explained to the class. Making my way from group to group, I found myself working alongside students, demonstrating how to read some of the diagrams. I often demonstrated my thinking by talking aloud, as I pointed to features of the diagrams. I would ask questions such as, "I wonder what these arrows right here might mean? I think they show how heat is getting trapped? What do you think?" As I engaged in exploratory talk (Barnes, 2008), I listened to what my students understood concerning their diagrams and provided additional demonstrations I felt were needed to nudge them towards a better understanding of their diagrams.

When I asked my students to find diagrams of global warming, read, and explain those diagrams, it would have been irresponsible to insist they understood how to read those diagrams on their own without assistance. While many diagrams use symbols that are universal, many contain symbols unique to that particular discipline. Just like I can provide demonstrations for reading picture books or chapter books through language experience activities (Weaver, 1994) or think alouds (Keene, 2012), my job was to provide the same kinds of demonstrations students needed to make better sense of diagrams, and more important, reading the world.

Demonstrating the skillfulness of inquiry. Science and inquiry are perfect companions because processes such as observing, asking questions, discovery, and exploration is what science and inquiry are about (DuVall, 2001). Jennings and Mills (2009) defines the skillfulness of inquiry as any strategy or tool used to inquire. This definition is open-ended because how one comes to understand anything, including scientists, is vast and changes as new strategies and tools are created and re-created. Jennings and Mills state that some examples of the skillfulness of inquiry involve using primary and secondary sources, wondering, generating questions, collecting data, reflection, and talk (Jennings & Mills, 2009; Mills, 2014; Mills et al., 2014).

Dr. Helmuth and his colleagues demonstrated the skillfulness of inquiry on numerous occasions. As marine biologists and climatologists, Dr. Helmuth and his colleague's primary purpose was to inquire into how marine life along the Oregon coast was impacted by climate change. A number of tools were used to collect data. For example, data loggers were used to document changes in water temperature, data sensors for documenting the stress levels of marine life, and a number of measuring devices were used to measure distances and the size of various marine life (see Figure 4.7).

Besides tools, Dr. Helmuth and his colleagues demonstrated how to record a variety of data. Data were usually collected in groups of two or three. One or two people would take measurements while another would write the information in small, waterproof journals. Simple tools were used to record data such as rulers and measuring tapes. Depending on the type of data being recorded, a table was created on the spot to organize

Figure 4.7. Small caliper used to measure the size of mussels.

the information. In Figure 4.8, Tim and Susan pulled pisasters from the rocks. Tim measured each arm of the pisaster, noted its color, and its location to prey. Susan helped Tim with data collection and Susanne recorded this data in her journal**.**

Figure 4.8. Tim and Susan collected information while Susanne recorded the data.

Ally demonstrated how she collected, recorded, and organized data. At Boiler Bay, Dr. Helmuth and his colleagues placed data loggers in a variety of places in order to collect temperature. Information on each data logger , was recorded in a journal. The information that was collected was organized and plotted onto a map of the Boiler Bay

Figure 4.9. Data was collected, coded, and organized.

area (see Figure 4.10). Organizing data loggers on the map helped Dr. Helmuth recover loggers and aided in data analysis. It was important for his team to plot temperatures to see how they affected the entire population of organisms and not just a specific point.

How my understanding of the skillfulness of inquiry influenced classroom decisions. Bruner (1961) believed there appeared to be "a series of activities and attitudes, some directly related to a particular subject and some fairly generalized, that go with inquiry and research" (p. 30). This statement helped me re-envision what it means to be an inquirer and teacher of inquirers. As an inquirer, it helped affirm a variety of strategies I utilized to help construct knowledge of the world around me such as where to find credible information, compare and contrast a variety of information to make informed decisions, and ask questions from a variety of perspectives. As a teacher of inquirers, when Jennings and Mills (2009) and Mills (2014) shared ways that teachers demonstrated the skillfulness of inquiry in the classroom, inquiry turned to something I

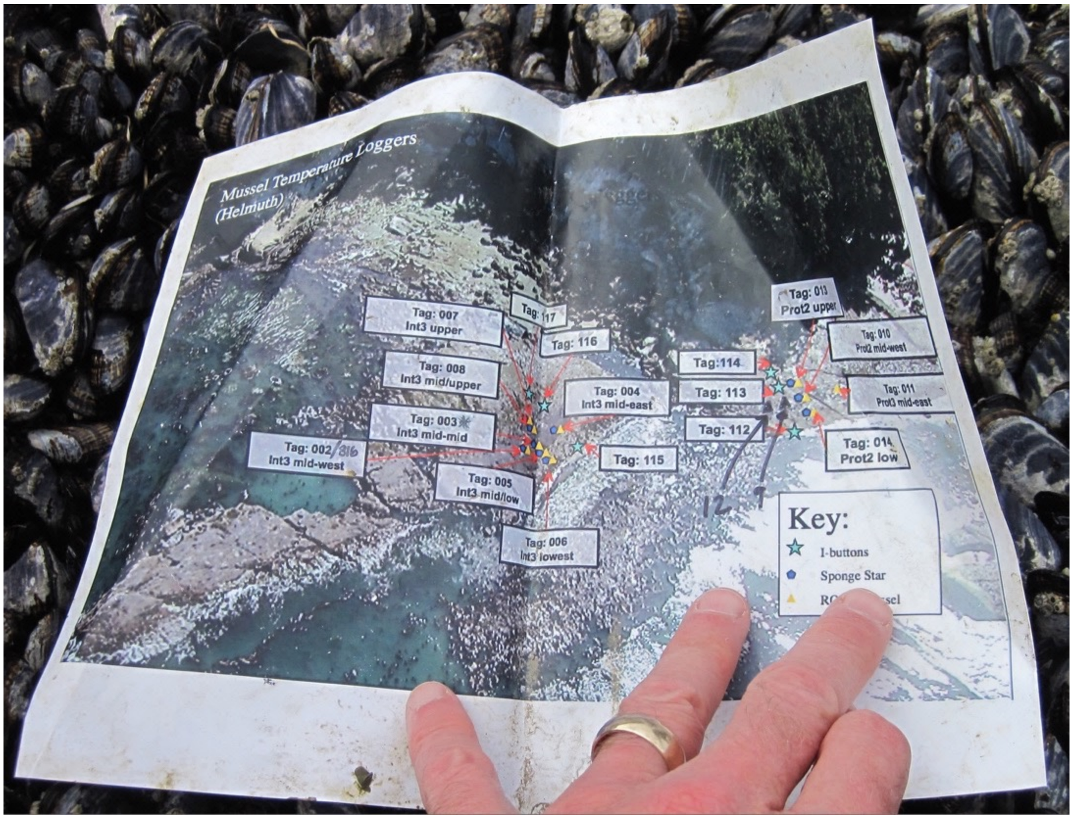

Figure 4.10. Data loggers were plotted on a map.

could apprentice students into. When I demonstrated the skillfulness of inquiry, I personalized and democratized inquiry by empowering learners to embrace strategies that helped them construct knowledge in ways that were personal and meaningful to them.

For example, before beginning this unit of study, I understood that a unit of study such as climate change would involve reading lots of non-fiction and could potentially be debatable due to the political nature of the topic. To set the tone of this unit of study, I asked students to develop definitions of non-fiction as a means of using prior knowledge in conjunction with researching to construct new knowledge. Students formed small groups in order to share and gather information gathered from multiple sources. These sources included information gathered online and from personal definitions of non-fiction.

As students developed their definitions, I pulled a non-fiction book called *The Mystery of UFOs* (Oxade, 2006) from my *Can Science Solve?* bin. This series of books uses science to discuss the validity of topics such as UFOs, the Bermuda Triangle, and haunted houses. Even though these books are considered non-fiction, the topics they discuss can be perceived as *false* depending on the beliefs of the individual.

After ten minutes, I walked to the whiteboard and asked students for their definitions. As students shared I recorded their definitions (see Figure 4.11). One group shared that non-fiction was the "opposite of fiction," while another group shared that non-fiction was "true information". Overall as a group, students defined non-fiction as "truth", "accurate", "real information", and "containing facts". Immediately after writing their definitions, I asked the class how many people believed in UFOs. Three or four students raised their hands including Peter. I posed a question to the class, "If Peter was reading a book on UFOs, would he believe the information he was reading was non-fiction or fiction?" Everyone said it would be non-fiction. Then I asked if Jaci, one of the students who did not believe in UFOs, was reading the same book, "…would she think it is non-fiction or fiction?" Everyone said it would be fiction. This is when students started to murmur – how could a book be fiction and non-fiction? I challenged students that non-fiction is based on truth and factual information, but it is grounded in what the reader *perceives* as truth. I then shared with students that we would be studying climate change, and the best way to uncover truth about climate change was by engaging in personal inquiry and in the process, further developing the skillfulness of inquiry so that students could “…find out the information on your own and come to your own conclusion” (Anecdotal Notes – 1/07/13).

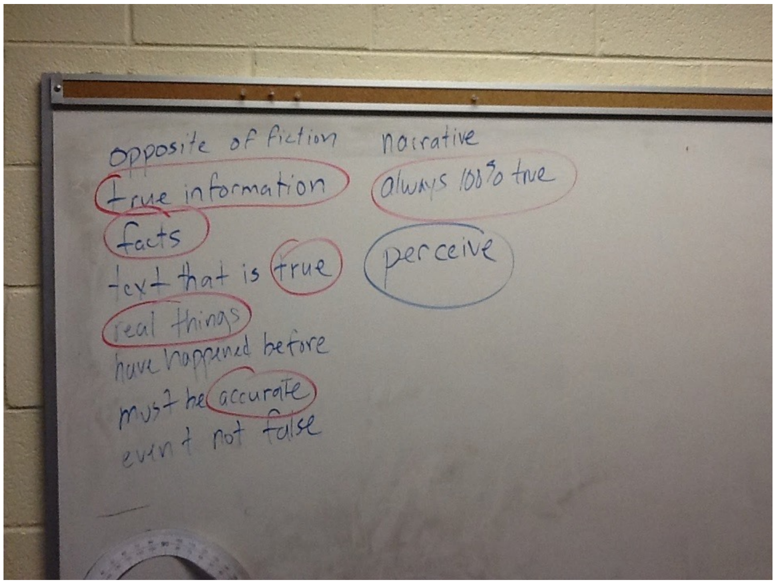

Figure 4.11. Students' definitions of non-fiction.

Knowing-in-action. While in Oregon, I came to appreciate the vast knowledge Dr. Helmuth and his colleagues possessed concerning their areas of expertise. They were experts in their respected field with an immense knowledge of the area. As Center for Inquiry teachers explored the intertidal zone, we pointed out things that interested us and asked questions. Dr. Helmuth and his colleagues were more than happy to answer our questions. Their words and actions were spontaneous, yet grounded in their expertise. Dr. Helmuth and his colleagues’ responsiveness to our questions and wonderings made the Oregon experience rich and gratifying.

When apprenticing under the guidance of those with more experience, you want them to be knowledgeable individuals who have a great deal of understanding in their particular area. Not only do you want them to be knowledgeable, but they must also be able to share that knowledge in a manner that is engaging and authentic to newcomers. While this is not necessary for learning to take place, since we can learn from those with less experience, apprenticing under knowledgeable individuals often means their actions are guided by their knowledge and past experiences. Schön (1983, 1992) defines this action as *knowing-in-action*. Knowing-in-action describes the "knowing [that is] built into and revealed by our performances of everyday routines of action" (Schön, 1992, p. 124). In other words, knowing-in-action describes the application of one's knowledge (Schön, 1983). This is the knowledge that is often attributed to professionals or those who have a great deal of knowledge in their particular area of study.

While I have referred to this as *improvisation* or *spontaneity*, Schön often describes knowing-in-action as *intuition* or *instinct* (Schön, 1983). No matter how it is defined, knowing-in-action reveals our knowledge and understanding. Individual's actions, including those with more experience, are guided by their knowledge and experience. They can modify and change their actions to fit a particular context and its' changing conditions (Schön, 1992).

While in Oregon, we often worked with Ally, a graduate-student working alongside Dr. Helmuth in the intertidal zone. Ally possessed tacit knowledge concerning the intertidal zone and the organisms found within the intertidal zone. When she conducted research in the intertidal zone, certain methods of experimentation were first attempted in the laboratory before trying them in the field. All variables were considered in the laboratory before heading into the field. Unfortunately, the intertidal zone is constantly shifting which meant the same methods of experimentation used in the laboratory changed based on the prevailing conditions. For instance, Ally brought equipment to measure stress levels of mussels located in the mussel beds within the intertidal zone (see Figure 4.12). Their equipment is often used in the laboratory where they create conditions designed to purposely stress mussels. When the equipment was set up in the field, Ally had difficulty gathering stress levels. Mussels either became too stressed and their hearts stopped beating, or there was interference with the equipment. Using her knowledge of the field, the equipment, and mussels in the intertidal zone, Ally relied on her knowing-in-action to make adjustments to fit the unpredictable conditions of the field and the changing conditions in an attempt to collect data.

Figure 4.12. Ally's knowing-in-action allowed her to make adjustments to changing conditions.

How my understanding of knowing-in-action influenced classroom decisions. I used to be a teacher who was scared of spontaneity. I felt that spontaneity in the classroom led to misunderstandings of the task and classroom behavior diminished. It was easier to strategically plan each lesson. After all, only through clear and concise planning could I account for all variables. As I gained more classroom experience, I came to understand that classrooms are not static environments and it is impossible to account for all variables. You never know when a child will get sick or act out which causes a critical mass to laugh uncontrollably. At the same time, a child might ask a question that pushes the classroom to think from a different perspective or make a connection that leaves you dumbfounded. If my instruction does not move and sway with the natural learning and responses from my students, then I am not responding to the needs of my students. In the words of Ken Goodman (2014), “Instruction must be a response to learning rather than limiting learning to a response to instruction” (para. 22). My goal as teacher is to respond to my students’ needs without feeling bound by instructional plans.

As an example, one of my lesson plans stated that after students read and made sense of their greenhouse effect diagrams, we would immediately move onto looking at greenhouse gases. As I monitored students, the second group I encountered was having difficulty making sense of their diagram. Chris attempted to explain a diagram he found but was having much difficulty. After providing some words of encouragement to continue working on it, I moved to another group. Beth and Jeena were having difficulty making sense of their diagram as well. We collaboratively constructed knowledge after several minutes of talking through their diagrams. In the midst of working with Beth and Jeena I came to the conclusion that if this many students were having difficulty making sense of their diagrams, I should have provided demonstrations that may help students.

I immediately asked students to put away their laptops and face the front of the classroom. I intentionally demonstrated the same process I asked my students to engage in. I did an internet search for the *greenhouse effect*. Next, I clicked on *images* and a variety of diagrams were displayed. I spontaneously clicked on the first diagram, placed it on the white board, and attempted to do a think aloud (Keene, 2012). I quickly realized this diagram was not helping me make sense of the greenhouse effect and shared my lack of misunderstanding with the class. I continued scrolling through more diagrams. I stopped on another diagram that looked familiar, placed it on the whiteboard, and talked through my understanding of the diagram with my students.

My knowing-in-action played a major role in *how* I responded to my students. The more professional knowledge I gained through reading professional books, participating in curricular conversations, or engaging in teacher-research, the better I evaluated particular situations, making changes to my instruction in the midst, and being spontaneous to surprise. It is this kind of mentor I desired to be as my students apprenticed under my guidance. These ephemeral moments of inquiry led to better quality of instruction and meaningful knowledge construction.

Observing and pitching in. If knowing-in-action guides the actions of teachers, then observing and pitching should guide the actions of our students. Through observing and pitching in, learning is an active process that takes place in the context of everyday activities within family and community life (Paradise & Rogoff, 2009). Lave and Wenger (1991) describe this active process as *legitimate peripheral participation*. Legitimate peripheral participation, similar to the apprenticeship model, is a mode of engagement in which newcomers perform the same tasks more experienced members engage in "but only to a limited degree and with limited responsibility for the ultimate product as a whole" (Lave & Wenger, 1991, p. 14). When newcomers participate in cultural activities alongside more experienced members of that group, they are expected to observe with keen attention to the events taking place. This often occurs spontaneously as newcomers come to understand the importance of the events they perceive. Observing with keen attention also comes about as newcomers attempt to fit into the same community that engages in those activities (Paradise & Rogoff, 2009).

Talk plays an important role in observing and pitching in since talk is used to support the engagements of newcomers. In these situations, talk is used to give directions, ask questions to facilitate understanding, or to clarify miscues in understanding. No matter how talk is used, it is not meant to be a substitute for participation in the activity. Rather, talk is used to facilitate the task, in the midst of the task (Paradise & Rogoff, 2009).

In Oregon, observing and pitching in played a major role in our apprenticing under Dr. Helmuth and his colleagues, as this was the primary means in which learning took place. As illustrated in Figure 4.13, Mackenzie demonstrated how to dissect mussels. At the same time, she used talk to explain the directions, she dissected mussels, pointing and explaining the various organs in the mussel. Amanda, Tammy, and Chris observed Mackenzie’s demonstration with keen attention. While Mackenzie talks, Amanda wrote down notes, Tammy used a tool that measured the size of the mussel, and Chris inspected some aluminum foil which contained dissected parts. As Mackenzie demonstrated how to dissect the mussel, Amanda, Tammy, and Chris were actively engaged in the demonstration through observing and pitching in when appropriate.

Figure 4.13. Mackenzie demonstrated while Amanda, Tammy, and Chris observed and pitched in.

How my understanding of observing and pitching in influenced classroom decisions. The role of observing and pitching in profoundly influenced how I organized my instruction in a manner I could get my students to fully participate. I assumed that participating meant doing some kind of hands-on activity. While hands-on activities are extremely important for children to understand daily tasks in their community, we should not focus solely on this aspect of learning as a sole means of getting students to participate in classroom activities. When students and teacher work alongside each other, they are just as involved in the learning as any hands-on lesson. When students and teacher work side-by-side, participants transact in shared endeavors, fully participating, and fully concentrating on the tasks at hand as they work towards a common goal or task.

Observing and pitching in was vital to understanding how to perform citizen science tasks and systematically collect the necessary data. A citizen science project the class participated in was collecting daily precipitation data using a low cost rain gauge. Emily volunteered to go outside, read the rain gauge, and upload the data to the Community Collaborative Rain, Hail, and Snow Network (www.CoCoRaHS.org) (see Figure 4.14). Each morning for a week I took her outside. Emily observed and pitched in when appropriate as she asked questions, measured the amount of rain, emptied the rain gauge, and attached the rain gauge to the post. She gradually took over the task until she could do so independently. After collecting the data, the information needed to be uploaded using the CoCoRaHS app. We worked together as I demonstrated how to use the app. Emily pitched in by inputting the data as I shared my understanding through talk.

Figure 4.14. Emily inputted data from the rain gauge.

She took ownership of the task as she gradually took over responsibility for inputting the data. In the process of coming to understand this task, Emily learned content and the process of data collection and input in concert.

Purpose and investment. When newcomers participate in the everyday life of their community, they understand their work has purpose and this motivates them. When they see their work has purpose, they are often invested in that work because they understand their work contributes to the community and the every day world they participate in (Paradise & Rogoff, 2009). Thus, the investment in the task is inherent in the activity.

While in Oregon, Dr. Helmuth created and organized experiences that were purposeful. Before heading to the Oregon coast, Dr. Helmuth talked with us about the data we were gathering and what that data would be used for. We had an understanding that the data we collected would be for authentic purposes – to be used by scientists for scientific reasoning. Because we understood the importance of our work, we were invested. We understood that the data we collected would play an important role in helping scientists across the country and the world, including Dr. Helmuth and his colleagues, make decisions in regard to climate change. By contributing to an international database, the purpose of our work provided a sense of investment.

How my understanding of purpose and investment influenced classroom decisions. While in Oregon I came to fully understand the importance purpose and investment plays in apprenticing under the guidance of more experienced individuals. Teachers from the Center for Inquiry, including myself, were extremely invested in our work because we understood the purpose of our work. This investment could have been influenced by the fact we collected data on the beautiful Oregon coast. But this only strengthens the argument that purpose and investment are influenced by the context in which learning takes place and the type of authentic experiences created in which individuals use real tools for real purposes. In fact, Lave and Wenger (1991) have proposed that learning is situated and that it best takes place within the same context in which it is applied using negotiated tools that apply to that particular task. In other words, when an individual wants to learn about being a marine biologist, it is best to learn in the same context marine biologists work using the same tools marine biologists use. Working under these conditions provided all the necessary motivation to be invested in the day-to-day community tasks of marine biologists.

I wanted my students to find purpose and be invested in their work in the classroom. Since I was unable to bring the intertidal zone to the classroom, I needed to find another means of creating a context in which my students found purpose and investment in the day-to-day workings of the classroom while at the same time, collecting data for authentic purposes. I found this level of engagement through citizen science.

My first year of incorporating citizen science work happened when we returned from Oregon. Dr. Helmuth helped us locate a citizen science project to work with called the USA-NPN (United States of America National Phenology Network). This group collects phenological (phenology refers to cyclical or seasonal events in plants and animals which occur on a yearly basis such as bird migration) information from around the country to see how climate change affects a variety of organisms such as tress and plants. Researchers, students, and volunteers collect observations. Patterns in the data are observed to see how climate change affects patterns in nature.

My classroom observed a cloned dogwood tree and a persimmon tree. USA-NPN provided plant phenophase datasheets (Figure 4.15). These datasheets ask observers to notice when leaf buds first break, when leaves begin to fall, and when fruit first appears (if it is a fruit-baring tree). Students, rotating on a schedule, would observe the cloned dogwood and persimmon tree and fill in the datasheet according to what they observed. Observations were then entered into our USA-NPN account and uploaded to their database. Scientists and researchers used this information to track for phenological changes in specific plants and animals across the country.

Trees and Shrubs *Deciduous*

Directions: Fill in the date and time in the top rows and circle the appropriate letter in the column below.
y (phenophase is occurring); **n** (phenophase is not occurring); **?** (not certain if the phenophase is occurring).
Do not circle anything if you did not check for the phenophase. In the adjacent blank, write in the appropriate measure of intensity or abundance for this phenophase.

nature's notebook

Species: Cornus florida-appalachianspring
Common Name: Appalachian Spring dogwood
Nickname: Appalachian Spring dogwood-1
Site: CFI - Johnson
Year: 2015
Observer: Scott Johnson

	Date:	Date:	Date:	Date:	Date:	Date:	Date:	Date:
Do you see...	Time:	Time:	Time:	Time:	Time:	Time:	Time:	Time:
Breaking leaf buds	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Leaves	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Increasing leaf size	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Colored leaves	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Falling leaves	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Flowers or flower buds	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Open flowers	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Fruits	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Ripe fruits	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Recent fruit or seed drop	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___	y n ? ___
Check when data entered online:	☐	☐	☐	☐	☐	☐	☐	☐
Comments:								

Plant Phenophase Datasheet

Taking the Pulse of Our Planet
Contact: nco@usanpn.org | More information: www.usanpn.org/how-observe

USA npn National Phenology Network

PAPERWORK REDUCTION ACT STATEMENT: In accordance with the Paperwork Reduction Act (44 U.S.C. 3501), please note the following. This information collection is authorized by Organic Act, 43 U.S.C. 31 et seq., 1879 and Fish and Wildlife Coordination Act. Your response is voluntary. We estimate that it will take approximately 2 minutes to make and report observations per respondent. An agency may not conduct or sponsor and a person is not required to respond to a collection of information unless it displays a currently valid Office of Management and Budget control number. OMB has reviewed and approved this information collection and assigned OMB Control Number 1028-0103. You may submit comments on any aspect of this information collection, including the accuracy of the estimated burden hours and suggestions to reduce this burden. Send your comments to: Information Collection Clearance Officer, U.S. Geological Survey, 12201 Sunrise Valley Drive, MS 807, Reston, VA 20192. OMB Control #: 1028-0103 Expiration Date: 01/31/2016

Figure 4.15. USA-NPN plant phenophase datasheet.

Independence. When newcomers apprentice under the guidance of a mentor or expert, newcomers participate in the same tasks the mentor or expert participates in.

Through this process the newcomer develops the language and processes of inquiry demonstrated by the mentor or expert (Mills, 2014). It is through this participation that newcomers change over time, until they begin to accomplish the task independently using the knowledge gained as a result of working alongside more experienced members. Rogoff (1995) calls this change *participatory appropriation* referring to the processes that transforms the newcomer's understanding and responsibility of the task. It is through this participation that newcomers change and become prepared to independently accomplish similar tasks (Mills, 2014).

During the Oregon experience, Dr. Helmuth's goal was for teachers to demonstrate their understanding of the experiences he organized, and then take ownership of the experience independently. When we first arrived in Oregon, Dr. Helmuth and his colleagues demonstrated how to pull tubes from the bottom of pisasters in order to collect DNA samples. Next, the tubes from these pisasters were collected and placed into small, plastic tubes. Through the teacher's participation in this experience, they were expected to take over the responsibilities of this task. As an example, Figure 4.16 shows Tim, Susan, and Susanne independently working together. Tim and Susan pull tubes from pisasters as Susanne writes down information such as the size and color, and location of the pisaster in proximity to its prey.

How my understanding of independence influenced classroom decisions. When it comes to learning, independence is a goal I have always had for my students. When my class studies the adding of fractions, my goal is to have all students independently add fractions; when we study the American Revolution, my goal is to have students independently demonstrate their understanding of the American Revolution.

Figure 4.16. CFI teachers independently collected data.

My view of independence has not changed, but how I support my students as I intentionally scaffold them towards independence has. Under the apprenticeship model, it is important that I identify myself as a mentor whose role is to facilitate my student's participation in cultural ways of being, referring to our school's culture of inquiry (Mills & Donnelly, 2001). As I guide my students, they come to understand their own processes of inquiring through the skillfulness of inquiry (Jennings & Mills, 2009), especially within the context of that particular task.

The independence exhibited by my students is best illustrated in the midst of their citizen science projects. When we first collected data on our cloned dogwood and persimmon tress, I first had to become familiar with the process for collecting data. As I participated in the process, I invited several students to learn alongside me (see Figure 4.17). We brought the data sheets out to recess and attempted to make connections between the observations we were asked to make and what we noticed of the cloned dogwood and persimmon trees. As we talked about what we noticed over the course of several weeks, we felt comfortable we were observing the correct phenophase stages.

Figure 4.17. Students independently recorded phenophase data.

Those students I worked alongside eventually took over the task of observing the cloned dogwood and persimmon tree. When seasons changed, and new phenophases were observed, I worked alongside those same students, making observations together and discussing our thoughts. As the year progressed, those students felt comfortable enough to independently take over the task of observing and inputting the phenophase data.

Oregon Apprenticeship Experience to Communities of Practice

As I came to analyze the features of the Oregon apprenticeship experience, I noticed that the apprenticeship experience was a smaller, yet important part of something much larger taking place in Oregon. While the apprenticeship experience explained how individuals and small groups of people came to construct knowledge, it did not explain the larger sense of togetherness and camaraderie that existed amongst the group, and how the group as a whole contributed to the learning of its members. The learning that took place was not passed on in a formalized manner from expert to novice but rather, took place in the activities participants engaged in. Learning took place in the midst of community.

First, Dr. Helmuth did more than create activities in which participants worked alongside each other – he created a genuine community. Not only did participants work and learn together as a community in the field, but also community was built and maintained when we returned to our home base. There, learning continued as we debriefed about the day's experiences and members shared personal stories about their work in the field. Learning ebbed and flowed through our talk in a natural, organic manner. Second, as community was built, members of the Oregon experience saw purpose and were invested in their work. They positioned themselves as learners, observing and pitching in when possible, as Dr. Helmuth and his colleagues provided demonstrations that showed teachers from the Center for Inquiry how scientists work. Dr. Helmuth and his colleagues demonstrated their knowing-in-action, using their tacit knowledge to make on the spot decisions in response to the ever-changing conditions in the field. Thirdly, Dr. Helmuth and his colleagues demonstrated the skillfulness of inquiry as they collected authentic data what would be used for real purposes. Finally, Dr. Helmuth had the expectation that all learners within this community would be able to independently take over the task and contribute to the knowledge constructed by the community.

This community that Dr. Helmuth helped to nurture can best be described as a community of practice (Lave & Wenger, 1991; Wenger, 1998). Members of this community constructed knowledge as they engaged in social practices through a constant process of legitimate peripheral participation (Hoadley, 2012; Lave & Wenger, 1991). Over time, participants in the community gradually took up its practices. For the teachers from the Center for Inquiry, living within the community, taking up the communities' practices, helped them learn about the life of scientists by living the life of scientists.

Approximating a Community of Practice During a Unit of Study on Climate Change

Charged with a renewed sense of wonder and awe for learning and the natural world, I decided to embark alongside my students in a unit of study on climate change (see Appendix D) upon returning from the Oregon experience. Watching Dr. Helmuth in Oregon raised my own self-awareness as a teacher, consciously helping me create particular conditions for inquiring.

With my new understanding of the community of practice, along with a better understanding of the apprenticeship experience, I wanted to approximate the conditions I uncovered in Oregon to help my students become active and reflective participants in their own learning. To facilitate our understanding of climate change, I created parallel structures in the classroom that approximated those structures found during the Oregon experience. Those features of the apprenticeship experience in Oregon and in my classroom were:

- Community activities
- Position self as a learner
- Learning through demonstrations
- Demonstrating the skillfulness of inquiry
- Knowing-in-action
- Observing and pitching in
- Purpose and investment
- Independence

The unit of study on climate change was divided into two parts: 1) constructing knowledge of climate change, global warming, and the greenhouse effect, and 2) evidence for and against climate change. In the following sections I will share excerpts from our unit of study on climate change in order to help the reader develop a sense of what we learned and how I was intentional about approximating features of the apprenticeship experience in Oregon into my classroom community and curriculum.

Constructing knowledge of climate change, global warming, and the greenhouse effect. In order for this unit of study on climate change to feel like a natural extension of what we normally study in fourth-grade, I contextualized it as a part of our unit of study on weather - a fourth-grade science strand in South Carolina. After our weather unit, I wanted to uncover what students already understood about climate change as well as intentionally set a tone that we would be inquiring into climate change as a community. Wells (1999) believes that one way to begin a unit of study should be through the use of whole-class reflective discussion. He states that whole-class discussion is particularly important to "fostering the development of the collaborative ethos of a community of inquiry, such discussion provides the setting…in which knowledge is co-constructed, as students and teacher together make meaning on the basis of each other's experiences" (Wells, 1999).

I started the unit through whole-class discussion by asking students, "What have you heard about climate change?" I followed this question by asking students if they have heard of climate change, what do they know about climate change, and where did they hear this information from? Students grabbed blank pieces of paper for a quick write. After writing, I asked students to share what they wrote. Alex shared, "Climate change is about how the temperature changes each day." Many students agreed with Alex. Jeena honestly shared, "I've never heard of it."

As the conversation drew to a close, Peter spoke for the first time. He said, "Global warming is what leads to climate change. I read, I read in a magazine that the Earth is getting warmer because of greenhouse gasses. And … and that is causing the Earth to warm." After his explanation, students murmured they had heard of global warming more than they had climate change. This conversation set the tone for the remainder of the unit of study. Just as Dr. Helmuth demonstrated, embracing the apprenticeship model meant moving in and out of mentor/apprentice roles and allowing my students to take the lead when appropriate.

Defining climate change. After gaining some background understanding of what students understood about climate change, I felt it was important that the class worked from a mutual definition of climate change. Mills (2014) states that classrooms make stronger connections to a particular topic or theme when they are allowed to think together. I handed each group a small stack of books on climate change as students sat at their table groups. Stacks of books and sticky notes were placed at each of the five table groups. I asked each group to spend at least 10 minutes going through their stack of books and look at how the authors defined climate change. They jotted down notes they thought would contribute to the class-wide definition as they looked through their stack of books (see Figure 4.18). At the end of the ten minutes, students moved to another table and looked through a different stack of books, adding to their notes.

Figure 4.18. Students developed a class-wide definition of climate change.

I noticed an opportunity to reinforce information that had been learned during a prior unit of study on non-fiction text features, as I constantly and consciously evaluated the lesson. My knowing-in-action (Schön, 1983; Schön, 1995) guided my making changes in the midst of the lesson and prepared me to be spontaneous. I reminded students to make sure they used their understanding of non-fiction text structures to aid in helping them find the needed information. I walked around to different groups demonstrating how to use text features such as the index, captions, table of contents, and glossary. Since students were doing much skimming to find information, I talked with several groups about skimming through the beginning of their book to find information that will help with a definition, since authors often define the topic at the beginning of a book to help the reader.

At the end of the lesson, students gathered in groups to look at their notes. They synthesized the information and began forming a definition. Two groups developed less of a definition but shared more of the causes of climate change. The next group came up with a definition that was close to a working definition. The final group shared a definition that was more geared towards global warming being the cause of climate change. Using the information gathered by all groups, we developed two working definitions (see Figure 4.19). This definition combined the knowledge generated by the classroom community as they combed through a variety of texts in search of how those authors defined climate change.

Students reflected on their understanding of climate change. After looking at the articles, I wanted to spend the remainder of our time intentionally having students reflect on what they understood about climate change. Chris Hass, a second grade teacher at the Center for Inquiry, uses *I Think I Know…* folders (see Figure 4.20) to get his students to

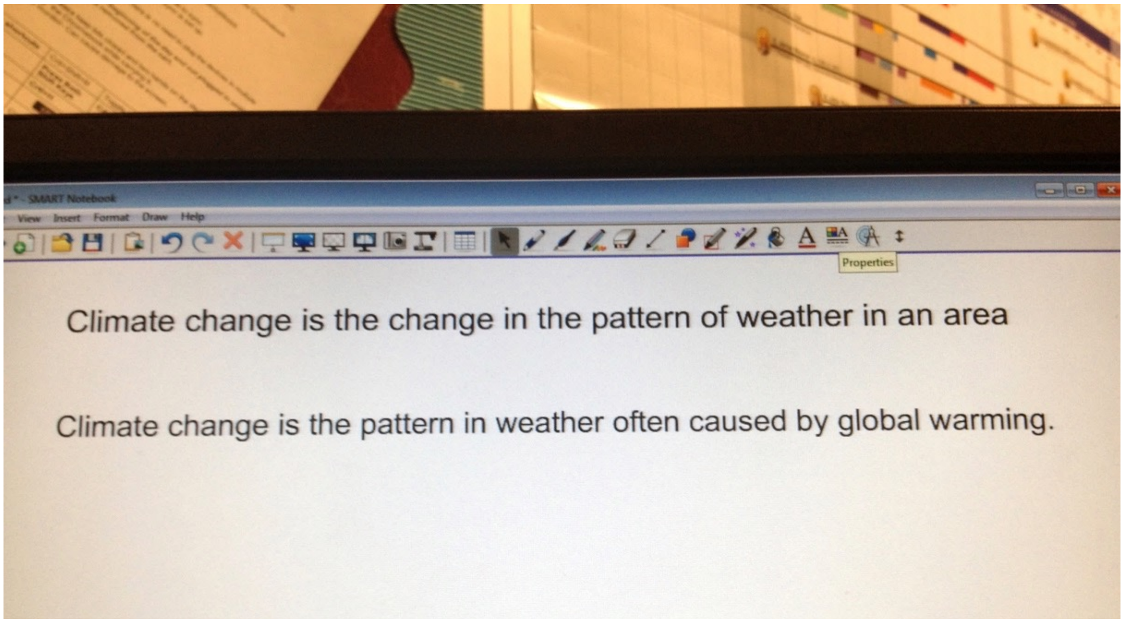

Figure 4.19. Working definition of climate change.

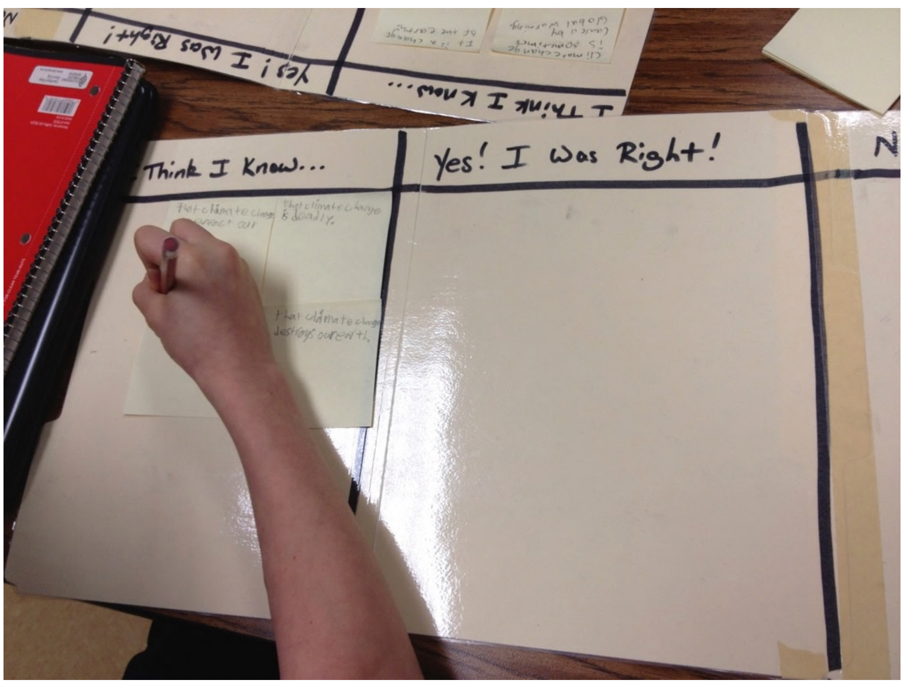

Figure 4.20. Reflecting through *I Think I Know...* folder.

document their understanding of a topic and reflect on how that understanding changes over time. Using the *I Think I Know…* folders (Mills, 2014), I gave students sticky notes to record their understanding of climate change based on the definition we developed. As students' understanding of climate change became more sophisticated over time, they moved their sticky notes to one of the columns.

I asked students to share one item at the end of ten minutes. Students shared a variety of wonderings and questions such as:

- I think . . . climate change affects animal hibernation?
- I think . . . climate change has a big impact on humans?
- I think . . . climate change affects the economy?
- I think . . . climate change can be dangerous?
- I think . . . climate change can be seen in the weather?
- I think . . . climate change is weather around the world?
- I think . . . climate change affects our lives?

Emily's *I Think I Know…* folder (Figure 4.21) started with some basic, background understanding of climate change and its global effects as seen in Figure 4.22. As Emily periodically reflected on her understanding of climate change, she came to understand the

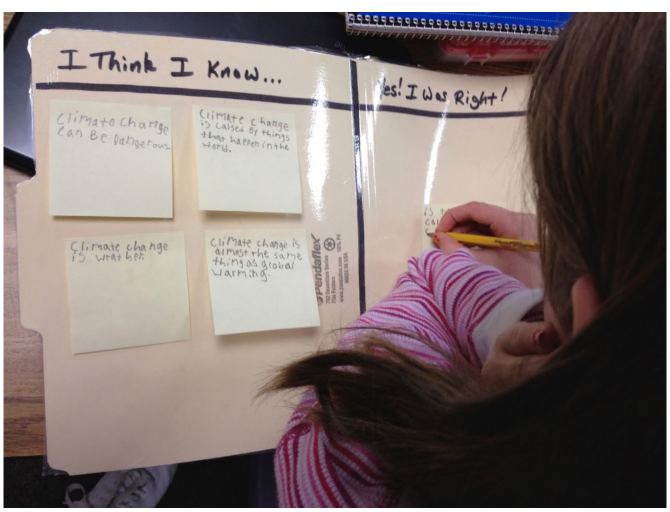

Figure 4.21. Emily documented her thinking by reflecting on her prior knowledge of climate change.

tentative nature of knowledge. For instance, as Emily's understanding of climate change developed during the course of the unit of study, her background knowledge was confirmed as her sticky note "Climate change is caused by things that happen in the world" and "Climate change is weather" are moved from the *I Think I Know…* column to the *Yes! I Was Right!* column (Figure 4.23). As Emily continued to reflect, she also realized that her comment "Climate change is almost the same thing as global warming" was inaccurate and she moved this note to the *I Was So Wrong!* column.

I Think I Know…	
Climate change can be dangerous.	Climate change is caused by things that happen in the world.
Climate change is weather.	Climate change is almost the same thing as global warming.

Figure 4.22. Emily's initial understanding of climate change as written in her *I Think I Know...* folder.

The *I Think I Know…* folder also allowed Emily to document her thinking as her understanding of climate change became more sophisticated. In the *New Facts* column, Emily reflected on what she understood and documented her new understanding (see Appendix E for full transcript of Emily's *I Think I Know…* folder). She understood that "Climate change is making animals migrate and changing the environment" and "Climate

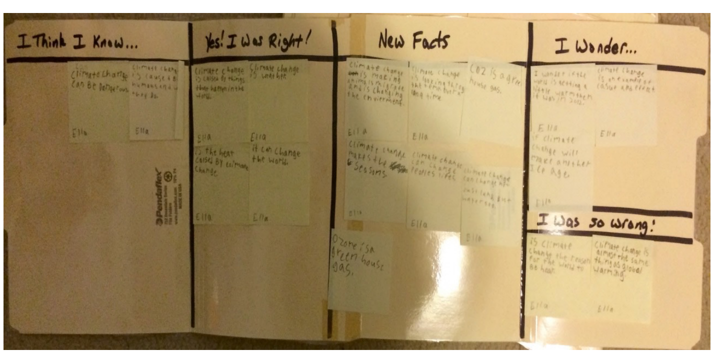

Figure 4.23. Emily's *I Think I Know...* folder reflected her thinking as it became more sophisticated over time.

change is looking through the temp. over a long time" (see Appendix E). Eventually, new understandings built upon prior knowledge as Emily's reflections turned into *I Wonder…* statements. Emily wondered "if the world is getting a little warm[er] then it was in 2012" and she wanted to know "if climate change will make another Ice Age" (see Appendix E).

To facilitate the building of a strong community of inquiry, I purposely ended this time of reflection by having students share their sticky notes (see Figure 4.24). Mills

Figure 4.24. Marissa shared her thinking.

(2014) believes that in strong classroom communities students are allowed to be open and honest when they share aloud. It was important for all students to openly and honestly share their current understanding. When students heard from others how they think, it built a sense of connection between individuals and the group as a whole, while confirming and revising their thinking.

Defining global warming. I felt building on prior knowledge was foundational for this unit so students could get a sense of the direction we were moving in our unit of study. Before we began to work I always reminded them where we left off the prior week. We reflected on the articles on climate change and reviewed some of the questions that were generated. One of the questions that appeared several times was, “What is global warming?” This information-seeking question served as a frame for the information we would need to find in order to answer this question. Lakoff (2004) states that, “Frames are mental structures that shape the way we see the world. As a result, they shape the goals we seek” (p. xv). Similar to guiding questions (Mills, 2014), information-seeking questions guide and frame the type of information that needs to be found in order to address the question. While these kinds of questions limit the amount of information students need to find to answer a question, *how* they answer the question remains open-ended in order to honor multiple perspectives on the topic.

I asked the question “What is global warming?” to frame the discussion and deliberately engage students in the skillfulness of inquiry. Students were expected to synthesize information from a variety of books, or use several websites, to develop a working definition of global warming. Students were expected to write three to five bullets as to the causes of global warming as they uncovered information for their definition.

As students worked in groups, Maria decided to work by herself. She described in detail the greenhouse effect and how this was leading to global warming. When I asked how she figured this out, she showed me a diagram she had been reading. Maria used the diagram to talk through her understanding of the greenhouse effect and global warming. By using the diagram, Maria constructed knowledge of greenhouse gases and global warming in a quick and efficient manner. Framing the question allowed Maria to take the initiative to construct knowledge of global warming that made sense to her. She understood the purpose of the lesson and was invested in the work. The conversation I had with her provided some feedback that pushed her thinking. More important, positioning myself as a learner and allowing Maria to teach me about what is possible opened my eyes to new possibilities with this unit of study.

Students gathered together in a circle and groups shared the information they constructed. As students shared I recorded their information on the whiteboard. Based on their responses, students defined global warming as “The increase in the Earth’s temperature.”

Up to this point, students were focusing on using information from a variety of sources to get a better sense of some of the major terms we were learning about. While we were uncovering *some* information about climate change and global warming, it felt like the class was sifting through a beach worth of sand in order to find a particular pebble. We were sifting through an enormous amount of information but it was not clear whether anyone understood the information they uncovered. But for a new unit of study I had never engaged in, it was a jumping off point for new and exciting turns in our study.

The greenhouse effect, greenhouse gases, and reading diagrams. My transaction with Maria and her diagram nudged me to take greater action in making sure my students understood concepts such as climate change, global warming, greenhouse effect, and greenhouse gases. To do this, I wanted to engage in more exploratory talk with my students by deliberately apprenticing students into constructing knowledge through exploratory talk.

I began this part of our unit of study by asking the question, “What is the greenhouse effect?” I emailed students several websites they were to use to synthesize information. One group was already intently reading over the information found on one of the websites. Allana and Alexi were gathered around their laptops discussing some of the greenhouse gasses that are known to cause the greenhouse effect. I walked over and joined the conversation. Here is an excerpt of our conversation. For the full transcript see Appendix F:

> T: Well, I mean, what is your question? What is the greenhouse effect? Can you tell me what that is? And then, what are those greenhouse gases?
>
> A: I found, but, from what I read, I read, two different websites you sent me. They both had different
>
> Al: the meanings
>
> A: they both have different meanings because this one says, like, it’s a rise in some temperature (inaudible) gases in the atmosphere, and then it goes into that but then this one had different ones
>
> Al: it said the . . .
>
> T: but, but it’s all based on the same thing
>
> Al: [reads from website] “the atmosphere has gases and tiny amounts that trap heat from the (inaudible)”

T: So, so what we can easily say is greenhouse gases is due to certain gases in the atmosphere.

Al: Yea

T: and some of those gases do what? They . . .?

Al: they trap heat from the earth

T: They both, so they both say that, they just both say it differently.

Al: Oooohhhh

A: Like um . . .

T: but they're both, but they're both talking about gases, atmosphere, and trapping in heat. And this is, and actually this is the picture that Maria even showed me…

The exploratory conversation I engaged in with Allana and Alexi demonstrated students grappling with constructing knowledge from the available information. They might eventually come to their own conclusion, but my participation in the discussion provided an opportunity for students to talk through their understanding. I provided feedback that nurtured and nudged their thinking, while demonstrating how to take two seemingly contrary pieces of information and compare them.

This conversation led us to the same diagram Maria used to make sense of global warming. As Allana begins to read the diagram, she and I engaged in another exploratory conversation around the diagram:

Al: [reading the diagram] that's the sun, the gases are like right here, that some of the heat escapes into the, (inaudible) the atmosphere is right here so then the gases go in and they trap the heat right there so it goes back to earth

T: Exactly, so you have, you're right, have the sun, the sun [turns the computer]

Al: [reading the diagram] Like it escapes, into space, it goes into space and it goes to the, all the way down to the atmosphere. Then the, then the gases into the air and trap heat from the earth so it goes back

T: [pointing to diagram with Allana] So yea, the sun, it warms, it sends its rays to warm, the sun's rays warm the earth, Ok. Some of these rays, they bounce back, so they bounce off the earth, and they go back out. Sometimes they hit the clouds, sometimes these rays hit the clouds, but some heat escapes out into space

Al: and then it goes to space and then it goes all the way to the atmosphere

T: Well, I, I get what you're saying. So some of these rays, you're right, they come down and they bounce up but some of these rays don't go out into space, they get trapped inside here – why?

Al: Because of the atmosphere is, those greenhouse gases trap them.

T: Because those gases that are let out, they cause this blanket, so some of those rays don't leave and they get trapped inside. So some heat trapped by greenhouse gases and they travel back to the earth.

Just like my conversation with Maria, engaging in exploratory talk around the diagram helped Allana make sense of the diagram. The constant turn-taking (Lindfors, 1999) allowed us to play off of each other's comments. Sharing back and forth, some comments were meant to nudge Allana (T: Well, I, I get what you're saying. So some of these rays, you're right, they come down and they bounce up but some of these rays don't go out into space, they get trapped inside here – why?), while other comments provided feedback (T: Exactly, so you have, you're right, have the sun, the sun…).

By the end of the discussion, I got the sense that Allana and Alexi were in the midst of understanding the concepts of greenhouse gases and the greenhouse effect. It was at this time I discovered that Mary was eavesdropping, intently listening, but not quite participating:

A: So the greenhouse, so when the sun [sends it] rays, some of the heat escapes into space which is brought back down to earth because of the greenhouse gases such as carbon dioxide and that kind of thing. Because it releases it so, so it [goes] back down to earth?

T: So yea, so some of those, you see those little black dots on that diagram, that represents the gases that, that are in the air. And we always will have carbon dioxide and those gases, um, um, if you

Al: and some of the chemicals there, carbon dioxide and I've seen like bleach, they have carbon dioxide in that.

T: Yea, so while the heat, while the sun heats up the earth, a lot of the heat escapes back into space but because of some of those gases it forms like a blanket and so some of that heat that should be going out into space gets trapped in that blanket and goes back down to earth and continues warming it

M: Oh, I get it.

Al: Yea, so it's like

T: I'm going to show you an experiment tomorrow to show you the effect of it. But one of the ways, the best, honestly the best way that I read about it. Imagine yourself in the summer.

Al: like it's hot

T: and this is horrible, imagine yourself in the summer, and oh, goodness gracious, dad locked, left you in the car

Al: Ohh

T: and the windows are down [I meant up]. So what's going to happen inside of that?

Al: it's going to get hot

T: Is it going to be hotter inside that car or outside that car?

A**,** An**,** M: Hot, it's going to be hot inside that car.

T: Why?

Al: Because the heat is trapped inside

T: the heat is trapped inside.

M: Oh yea, because everything is closed.

T: And it can't circulate. At least outside you can have some fresh air – not in the car.

Al: [sounding goofy and changing her voice]

A: I have another, I have something else. Cause like, when it was hot before, before it go, well there is two different points cause in the summer time, the car, when you get in the car, like if you are getting picked up or something, like when I go out it's really hot because it's been sitting, because it's sitting there all day and if, even, even if you have the windows closed that just traps more heat inside, it traps the heat that was already in the car, inside the car, and then like, if it's on a winter day it would be less cold because, um, it still traps the heat.

This conversation proved to be exciting because it demonstrated that students were attempting to construct their own knowledge through exploratory talk with the help of myself. Not only did students continue the same patterns in talk I previously shared, but they were attempting to summarize their thoughts, accept feedback for their approximations, and connect newly learned information with prior knowledge. To help students come to understand the concept of the greenhouse effect, I intentionally created the metaphor of imagining being trapped inside a car with the windows up. Alexi built upon my metaphor with an example of heat being trapped in a car during the summer and winter months.

After my work with Allana, Alexi, and Mary, I decided to continue learning about the greenhouse effect and greenhouse gases through diagrams. Since Allana, Alexi, and Mary used each other to come to new understandings through their diagram, I deliberately wanted this diagram work to become a community activity.

Students were asked to work in small groups. The task was for each student to find a diagram that was meaningful to them, read the diagram and make sense of it, and share its meaning with their partner. Each member of each group was responsible for their own diagram. The caveat was that each person would be responsible for understanding their partner's diagrams. Groups would then place their diagrams into a presentation program to be shared with the rest of the class.

As students worked, I walked over to Alexi and Mary who were beautifully practicing their diagrams. But when I really started to listen to their conversation I noticed their talk seemed unnatural and contrived. Upon further inspection I noticed they were directly reading the words found on the diagram. I mentioned to them that I did not want them to read the words because I would be asking them what the diagram meant. I intentionally asked them to put the diagram into their own words and *speak from the heart*. The purpose was for students to internalize and take ownership of the diagram.

Several minutes later I asked Alexi and Mary, “So what do the diagrams mean?” They took notice of the arrows and talked of how one set of arrows represented heat from the sun, another arrow represented heat that escapes the atmosphere, and another arrow represents heat that is trapped by greenhouse gases (see Figure 4.25). They used the diagram and had a conversation about their understanding of the greenhouse effect. I provided demonstrations as to what they might need to notice to help them better make sense of the diagram. As I walked away I could hear Alexi and Mary talk with each other about what they were planning to say and how they might share their information with the rest of the class.

Figure 4.25. Alexi and Mary transacted with their diagrams.

Our class completed this phase of our unit by having each group share their diagrams with the class. Each group read their diagrams, practiced with their partner what and how they would share, and then presented their diagrams to the class by speaking from the heart. By presenting in this manner and emphasizing students speaking from the heart, I could get a sense of who understood their diagrams and the larger concepts of the greenhouse effect. As a result of the presentations, Figure 4.26 shows a whole-class organizer the classroom community created together that showed our understanding of the unit of study at that time.

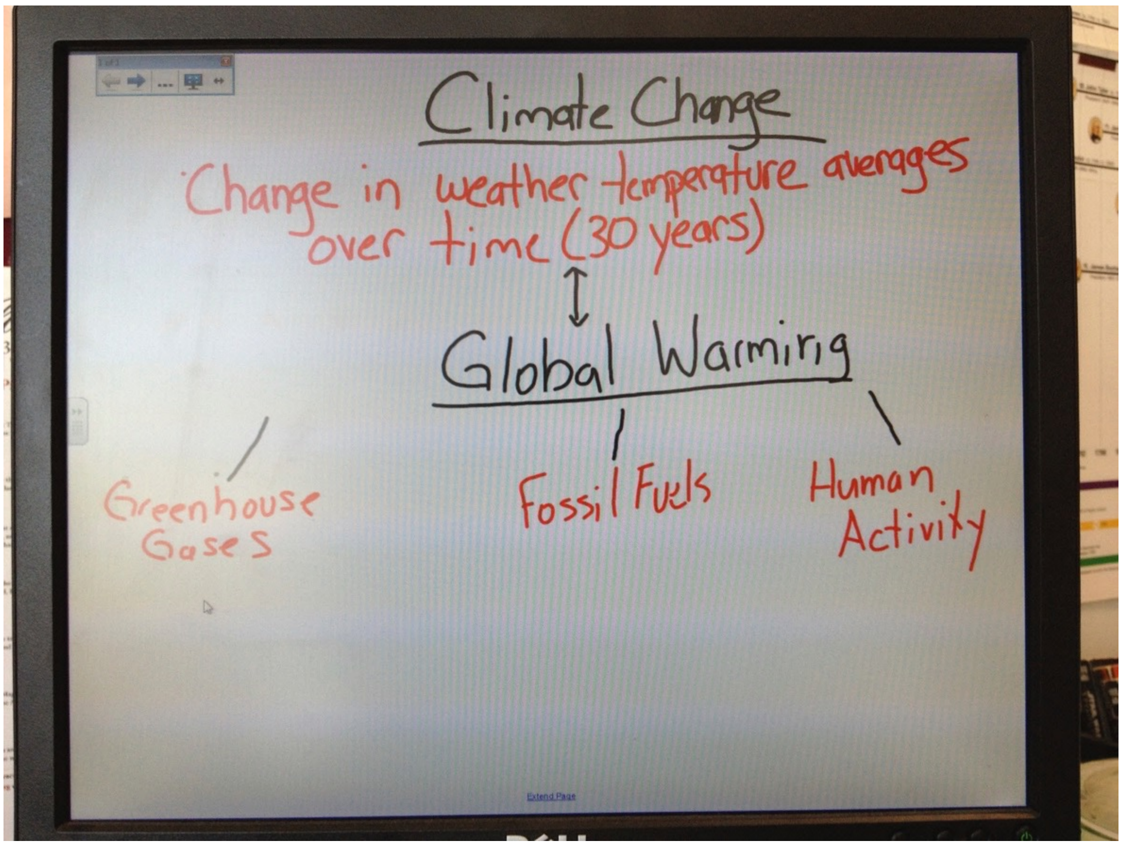

Figure 4.26. Classroom community created organizer of our understanding of climate change.

Evidence for and against climate change. Just like a long jumper needs a running start before he or she takes their big leap, my unit of study on climate change needed a running start to get going. Creating class-wide definitions was worthwhile because it demonstrated the skillfulness of inquiry and other features of the apprenticeship experience. But we could not survive on definitions alone. It was not until I positioned myself as a learner, and allowed Maria to demonstrate to me the power of using diagrams, that I felt my students really investing in the work. Next, Allana, Alexi, and Mary demonstrated that through exploratory talk, students actively attempted to construct knowledge. Finally, Alexi and Mary showed me that speaking from the heart acted as a window into children's understanding.

Learning to use the gigapan. Not only was it important for students to learn about climate change, but I wanted them to take action in some way. As a class we decided to document two areas of our school that contained trees we were accessing to collect citizen science data (I will share more about this citizen science project in Chapter 5). We understood that taking gigapan pictures would not prove or disprove climate change, but over time, we could compare what we noticed about the pictures with the date the picture was taken, the temperature at that time, and the phenophase data we collected.

Having tools for inquiring, such as the gigapan, was a unique experience for the class and I wanted students to have first-hand use of this tool. I decided to start by apprenticing Brandon into how to set up and use the gigapan (see Figure 4.27).

At first I immediately showed him the tripod and shared with him the importance of setting it up correctly so that pictures would be level. As I pointed to some of the features of the tripod such as the legs, he immediately began to observe what I was doing. While demonstrating how to lower the legs, Brandon grabbed the tripod and began to unlock the areas that would lower the legs. We practiced adjusting the legs so we could level the gigapan. Brandon pitched in as I showed him how to attach the gigapan to the camera. As soon as the tripod was set up I demonstrated how to attach the camera. Brandon grabbed a chair and moved it over to the gigapan so he could adjust the settings. Once we adjusted the gigapan and the settings, Brandon hit the go button and the camera took pictures.

Figure 4.27. Demonstrating to Brandon how to use the gigapan.

Having this practice, I asked Brandon to take the tripod outside and set it up for our first picture. Since Charles was interested in learning about the gigapan, I asked Brandon if he would apprentice Charles into how to set up the tripod. Observing them from the class window, both students got right to work. Brandon immediately opened the tripod, extending the legs about half way. Since Brandon and Charles were on the side of a slight hill, they made adjustments to the legs so the gigapan would be level. As they adjusted the legs, Brandon showed Charles the level on top of the tripod. Fifteen minutes later, I went outside to check on their progress. Everything went well until I moved the camera to a different position. Brandon and Charles immediately went back to adjusting the legs and leveling the tripod. We attached the gigapan to the tripod and I demonstrated to Charles, with Brandon observing, how to program the gigapan. Charles immediately made various adjustments to the gigapan and the camera. Before we pushed the start button, Charles noticed the tripod was not level– the weight of the gigapan caused the tripod to droop. Brandon and Charles took the initiative to make adjustments to the tripod and gigapan in order to level the camera. Through participatory appropriation, Brandon and Charles became more independent as responsibility was gradually released to them. As they gained more experience using the gigapan, they became more independent.

Pictures of climate change. In order for students to reach a conclusion on climate change, it was important for us to look at a variety of evidence for and against climate change. One piece of evidence we looked at was through an app called "Painting with Time: Climate Change" (Red Hills Studio, 2012). This app contains seventeen time-sequenced pictures that illustrate such climate events as retreating glaciers, floods due to temperature increase, and drought.

I began framing the lesson, explaining a bit about where the pictures came from, and asking students to write down their reflections in their journals. I asked students to reflect on whether a particular picture demonstrates strong evidence for climate change, or whether a particular picture attempts to sensationalize climate change. In other words, as inquirers, I invited students to be skeptical, yet open to possibilities.

One particular picture got more response from students than other pictures. It was a picture taken several decades ago of a lake with a glacier. When you swipe the picture, it reveals what the lake looks like today – glacier-less. After showing the picture, I asked students to write down their thoughts in their reflection journal. Based on what she observed in the picture, Jaci immediately asked what time of the year the pictures were taken. She states that one picture looks like it was taken during the winter (the picture is in black and white) and the other picture elicits thoughts of summer with its lack of snow and deep, blue skies. She posits that the picture with the glacier was taken during the winter, when there is much snow and ice, and the picture in color was taken during the summer when it is too warm and the ice and snow melted. Based on this evidence, Jaci was skeptical that these contrasting pictures illustrated climate change. While her thoughts were logical, her conclusion was incorrect based on her knowledge of glaciers and cold weather climates.

Unbeknownst to the class, Jaci's skepticism and honesty nudged the class towards exploratory talk in which the class debated, critiqued, and picked apart each picture. Several students commented that the glacier was in Alaska and that it is cold year-round to support glaciers. Another child mentioned that glaciers do not appear and disappear on a yearly basis. As Jaci listens to her classmates' comments, she slowly begins to realize the fault in her logic. Members of this classroom community of learners supported her comments, and provided feedback so that Jaci could examine and modify her thinking.

As I came to understand that developing healthy talk was important in learning about the skillfulness of inquiry, I was more receptive to taking my time with this lesson and letting our talk dictate the time we spent with these pictures. I originally concluded this lesson would take a day; instead, we debated these pictures for four class sessions over a period of two weeks. The amount of talk proved to be foundational. As we talked through this lesson, we learned about climate change, learned how to debate and critique, and validated that it was all right to be skeptical as long as one's skepticism was backed up by evidence.

Creating and sharing diagrams. I asked students to create their own diagram in order to demonstrate their understanding of climate change. As a class we discussed what kinds of things should go into their diagrams. Students mentioned their diagrams should include information on the greenhouse effect, causes of global warming, and should include some words, but not be language heavy.

I wanted to be intentional about apprenticing students into thinking about their climate change diagrams. First, I talked to students about being meticulous when creating their diagrams. We were not in any hurry to finish so I wanted students to be mindful about what they included and excluded in their diagram. Next, I created my own diagram to demonstrate my expectations for this assignment. In a prior assignment, when we created diagrams in social studies, I made assumptions about what students would include in their diagrams without explicitly making my expectations clear. For this assignment I intentionally did not want to make assumptions but instead, make my expectations clear from the start.

I made a conscious decision not to make my diagram before we started the assignment so that my diagram was not viewed as the model diagram. Instead, I had students work on a rough draft of their diagram for several days. As they worked without my assistance, I created my diagram. The intention of my diagram was to demonstrate what was possible, as well as demonstrating the expectations of the assignment.

Students seemed to perk up as I shared my diagram. I pointed out why I used arrows a certain way, what the colors in my diagram represented, and why I chose to include and exclude certain pieces of information. Instead of imitating my diagram, my diagram was used more for comparison. Students compared their diagrams to my diagram to see if they were missing some of the expectations.

Just like we ask students to create rough drafts in writing in order to slow down and gather their thoughts about what they want to say and how they want to say it, I asked my students to do the same thing with their diagrams. I talked with students about their diagrams as they neared completion of their work. For example, as Emily and Katie completed their rough draft, we talked about how their rough draft was too dependent on language to carry the meaning and needed to be reorganized in a manner that limited the amount of words. This created additional space so more information could be added. Using my diagram, I talked with them about why I made the earth in my diagram smaller so I had more space to represent the atmosphere and greenhouse gases. I helped them tape multiple pieces of paper together so they had more space for their words and drawings, and they began working on a final draft.

Figure 4.28 shows Emily and Katie’s final draft of their diagram. When they completed this draft, I asked them to use their diagram to explain climate change. Emily and Katie played off of each other as they explained elements of their chart. They

Figure 4.28. Emily and Katie's diagram of climate change.

explained that all the little red arrows represented greenhouse gases caused by their emission through deforestation and the burning of fossil fuels. Once they shared with me what many of the representations meant, they talked through their understanding of climate change:

> E: Some of the sun's rays come down and heats up the earth and others bounce off the atmosphere and back into space
>
> K: Yea!
>
> T: Ok.
>
> K: The factory is giving off CO_2.
>
> T: What does the CO_2 do?
>
> E: It's a greenhouse gas.
>
> T: And it does what?
>
> K: It warms up the earth and, well, like the humans, um, all these represent CO_2 like the gasoline does too, the gasoline…
>
> T: But what does the increase in CO_2 do?
>
> K: It warms the earth. It goes into the atmosphere.
>
> T: Then it traps…
>
> E: it traps the heat.
>
> K: It traps the heat in the earth and it warms the earth.
>
> E: We also call this global warming.

Through their diagrams, students such as Emily and Katie created representations of their understanding using signs supported by their talk. Creating the diagrams allowed children time to slowly reflect on their understanding and create a visual of their understanding. Creating the diagram facilitated a reflective conversation - I could gauge their understanding of climate change, through our talk, better than any form of computerized or paper test.

Statement of one's beliefs. As we came to the end of the year I wanted students to compose a piece of writing that stated what they believed about climate change, why they believed the way they did, and provide evidence from our studies to support their beliefs. These statements were extremely eye opening as they opened a window into what my students understood about climate change as a result of synthesizing the evidence for and against climate change. I have chosen three statements to share that serve as representative examples of the class. While all three statements drew similar conclusions (climate change is happening and humans are contributing towards climate change in some manner), how each child came to that conclusion differs based on the evidence *they* found conclusive.

What the evidence shows. Hannah (see Appendix G), Beth (Appendix H), and Alex (Appendix I) believed that humans contributed to climate change due to the over-reliance of burning fossil fuels such as carbon dioxide (CO_2) and greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O). Hannah and Alex stated that burning fossil fuels releases carbon dioxide, which is a greenhouse gas. For example, Hannah detailed,

> …fossil fuels relese CO_2 and sometimes methane, and people also cut down trees and trees breath in CO_2 and breath out oxagen and we need oxagen to live and we breath out CO_2 so if we don't have enogh trees to breath in CO_2 there will be to much CO_2 in the air.

Hannah felt that cutting down trees was harmful to the environment since trees absorb carbon dioxide and gives off oxygen. Alex felt methane was an extremely harmful greenhouse gas after reading an article about how each cow contribute three thousand pounds of methane per year into the atmosphere. Alex stated, “Mathine [methane] is a biggest too. It comes from waste most of it comes cow farts. They purduse [produce] 3,000 pound per year per cow. Also mathine [methane] is bad for the air.”

We watched a documentary by Bjørn Lomborg who felt climate change is taking place but felt there were bigger priorities. Al Gore also believes that climate change is taking place, it should be a priority, and the only way to save the planet is by spending billions of dollars on reducing carbon dioxide emissions. Beth and Alex’s statements referenced Bjørn Lomborg and Al Gore. Beth felt that both individuals brought up good points, though they seemed to agree with Bjørn Lomborg - there is a prioritized list of needs that include finding cures for world diseases, helping people lead healthier lives, and world hunger. Beth shared, “However Bjorn wants to use the money to fix climate change for diaseises [diseases] and make people more healthy to save the earth.”

All three students felt the pictures of glaciers, before and after, were conclusive evidence towards global warming. Hannah believed the pictures of melted glaciers did not prove humans were influencing global warming, but proved the earth is warming. In her statement, Hannah stated, “…I think the photo’s are great modals showing how global warming is taking place, it’s not showing how humans are influsing [influencing] global warming.” Beth’s statement included disagreements with the arguments made by skeptics of climate change. One argument by skeptics was that the tools used to measure climate change were inaccurate. She believed the tools were accurate and the skeptics’ argument that the earth is actually cooling is false. Beth also did not agree with the skeptics because, “The skeptics say that the sun is [the] reason climate change is happening and that the data is not relieable [reliable] because ‘scientist could be making climate change up.’”

The point of asking students to write a statement of belief towards climate change was to get a glimpse into the knowledge they constructed throughout the unit of study on climate change. These statements allowed students to reflect on what they have learned and the evidence they believed was the most compelling in framing their current understanding (Mills et al., 2014).

Concluding the unit of study in this manner was good because I used their statements to notice lapses in my teaching or even missed opportunities to be more responsive. For instance, since few students mentioned the evidence skeptics used to argue against climate change, I question how thorough I was in presenting the skeptic’s side. In the same argument, there was not much information at the time presenting the skeptic’s argument against climate change. Maybe I missed an opportunity for students to conduct research synthesizing the information argued by skeptics? Their statements provided information that will make future units of study on climate change, and more important, my teaching, richer and more meaningful.

The unit of study on climate change demonstrated that students actively constructed knowledge when I intentionally focused on inquiry and the features of the apprenticeship experience in Oregon (see Table 4.1 for a comparison of the apprenticeship features between Oregon and my classroom). These features not only helped to nurture inquiry and new understandings concerning climate change, but these features helped me redefine how a classroom community constructs knowledge together.

In chapter 5, I will share how I redefined my classroom community based on my understanding of the features of the apprenticeship experience in Oregon and in my classroom, and how knowledge was constructed as a result of this new understanding. Next, based on my conscious awareness and implementation of these features of the apprenticeship experience, I will share how knowledge was constructed in Oregon, in my classroom during our unit of study on climate change, and how my new understanding impacted future classroom decisions.

Table 4.1

Comparison of the features of the apprenticeship experience in Oregon and classroom

Features of Apprenticeship Experience	Oregon	Classroom
Community Activities	• Individuals worked alongside or communicated with others • Teachers and scientists worked alongside dissecting mussels for DNA analysis	• Students collaboratively worked towards a common goal such as building an FM radio, using Snap Circuits, or creating presentations
Position self as a Learner	• Role of expert and novice were fluid • Dr. Helmuth positioned himself as learner to invite new experiences to influence understanding • Seven-legged pisaster nudged further inquiry	• Positioning myself as learner allowed Maria to teach me the importance of constructing knowledge through diagrams
Learning Through Demonstrations	• Experienced members provided demonstrations to newcomers • Dr. Helmuth and colleagues provided demonstrations of DNA collection	• Demonstrated how to read diagrams
Demonstrating the Skillfulness of Inquiry	• Tools used to collect data o *Data loggers and data sensors* o *Laser levels* o *Various measuring devices* • Data collection o *Ally demonstrated how data was collected, organized, and reported*	• As students developed a definition of non-fiction, I demonstrated the skillfulness of inquiry as I challenged students to uncover the truth about climate change by engaging in personal inquiry thus, developing the skillfulness of inquiry
Knowing-in-Action	• Actions guided by current knowledge and past experiences • Ally used her knowing-in-action to make adjustments to measuring instruments to adapt to prevailing conditions in the field	• Students' difficulty making sense of diagrams nudged me to intentionally make on the spot decision to change lesson plans and better demonstrate how to perform the task
Observing and Pitching In	• Played major role in apprenticing under Dr. Helmuth • Teachers from the CFI observed and pitched in as the dissection of mussels were demonstrated	• Citizen science work through the Community Collaborative Rain, Hail, and Snow Network (CoCoRHaS)

Purpose and Investment	• Newcomers invested in community activities when they understood their work had purpose • Data collection in Oregon had authentic purposes – to be used by the scientific community	• Citizen science work through the United States of American National Phenology Network
Independence	• Dr. Helmuth's goal was for teachers to independently take over data collection methods	• Students independently take over citizen science data collection methods

Chapter 5

Knowledge Construction in Oregon and in My Classroom

In this chapter I highlight the ways in which knowledge was constructed in Oregon, how my understanding of knowledge construction influenced classroom decisions, and how knowledge was constructed in my classroom community of inquiry. As I noticed parallels and connections between the community of practice Dr. Helmuth nurtured in Oregon, and my classroom, the data slowly revealed how knowledge was constructed in both contexts as participants inquired alongside one another.

As a reader, you will notice chapters 4 and 5 reflect a parallel text structure. Both chapters reveal how my study unfolded across each phase of data collection and interpretation across contexts. Building on chapter 4, each section in chapter 5 opens with an explanation of how knowledge was constructed in Oregon. Then I illustrate how my understanding of knowledge construction in Oregon influenced my classroom decisions. I conclude each section with a demonstration of how knowledge was constructed during our unit of study on climate change.

Identifying the features of the apprenticeship experience within the community of practice in Oregon helped me to consciously nurture inquiry and new understandings during the unit of study on climate change. Constant review of my data revealed that my classroom was a unique kind of community of practice. Classrooms create a special type of community since they engage in activities and experiences unlike other types of communities of practice. In fact, Wells (1999) believes that different practices are appropriate for different situations and contexts since they take into consideration the participants, problems, and resources of that particular practice. To understand the kind of community of practice my classroom was, I reflected on how my classroom's practice fit into Wenger's (1998) three dimensions of practice. I came to understand that my classroom community *mutually engaged* in inquiry as we sought to construct knowledge of our world through the *joint enterprise* of engaging in units of study around a particular topic such as climate change. As we inquired, we created a *shared repertoire* of resources, strategies, and tools learned through the skillfulness of inquiry.

I concluded that my classroom was a *classroom community of inquiry* (Mercer, 2002; Seixas, 1993; Sharp, 2007; Wells, 1999; Wells, 2001b). My classroom community of inquiry reflected a group of people who shared a concern or passion for inquiry (see Figure 5.1). Students took active and reflective roles in the development of their own, and

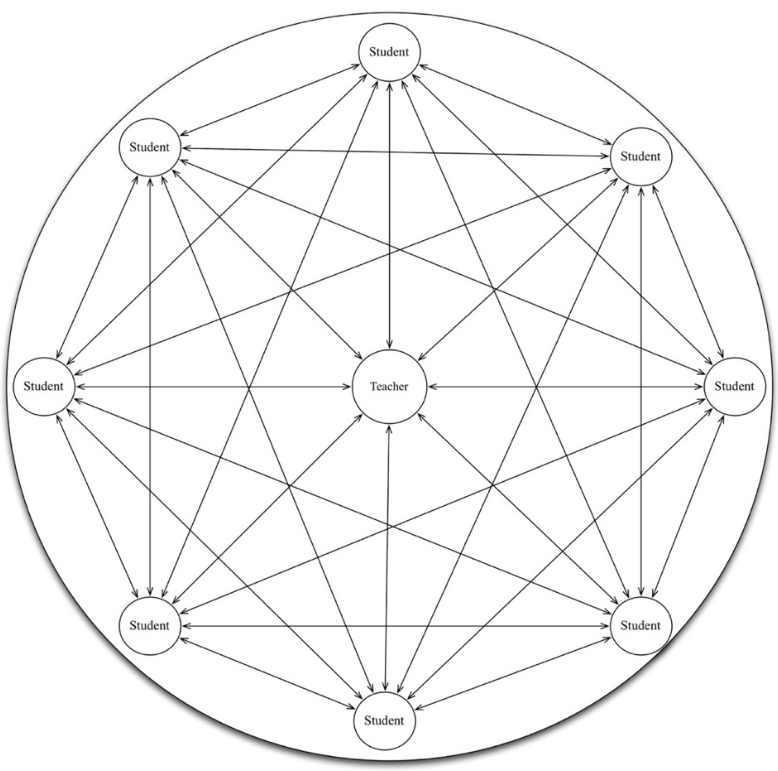

Figure 5.1. Classroom community of inquiry.

each other's understanding, through the unit of study on climate change, which was collaboratively negotiated between students and teacher. In this community, all members positioned themselves as teachers and learners. A shared repertoire of resources, strategies, and tools were constructed together through the skillfulness of inquiry, as students and teacher explored and investigated climate change through regular transactions and talk. As this chapter will demonstrate, in our classroom community of inquiry, knowledge was constructed in the following ways:

- Abductive reasoning
- Talk
- Transmediation
- Building upon prior knowledge and experience
- Observing and pitching in
- Reflection
- Purpose and investment

Watching Dr. Helmuth raised my own self-awareness as a teacher. Seeing him create particular conditions in Oregon consciously helped me create particular conditions for inquiring in my classroom. This allowed me to see parallels and connections between the Oregon experience and my classroom community of inquiry. The parallels and connections between the two learning contexts helped me intentionally make classroom decisions that facilitated the construction of knowledge during the unit of study on climate change. More than anything, identifying my classroom as a classroom community of inquiry helped me see it from a new perspective. I understood and appreciated my students' abilities to construct knowledge as a community as they wondered, sought answers to their questions, and interrogated new ideas and perspectives.

Knowledge Construction Across Contexts

Constructing knowledge through abductive reasoning. Abductive reasoning refers to the creative process of hypothesis generation (Stephens et al., 2000; Tshaepe, 2014) in which one reaches a general conclusion based on the evidence at hand. When we reason through abduction, knowledge is constructed and new ideas are created (Tshaepe, 2014) as we apply our past experiences to generate new rules or create order out of unique experiences (Shank, 1998). Important to abduction, is the individual and social component (Prawat, 1999). Dewey believed that inquiry is inherently social. The resolution of doubt or problematic situation does not take place in isolation. If is often resolved with the help of others. Dewey felt these individual inquirers are members of communities of inquiry, bound by certain agreements and responsibilities (Peirce, 2005). Once inquiry takes place, the inquirer enters into a contract such they will stand by their results until further reasons lead them to doubt, or problematic situations occur. While new ideas and knowledge are socially constructed, Dewey (1910) assigned the individual to validate the information since new ideas must be checked against the actual evidence.

Constructing knowledge through abductive reasoning in Oregon. Scientists constantly reason through abduction since abduction is about devising a theory based on studying the facts (Prawat, 1999). For Dr. Helmuth and his colleagues, their belief in climate change was influenced by the data. The data they collected in Oregon were analyzed and compared to data already in existence (Figure 5.2). Dr. Helmuth generates new hypotheses, or alters current ones, based on new evidence. While in Oregon, Dr.

Helmuth constantly shared new research findings in the field of climate change. As we collected data in the field, Dr. Helmuth would relate this data to current research findings.

How constructing knowledge through abductive reasoning influenced classroom decisions. While I am responsible for addressing state and local standards, how I address those standards is based on my professional experience and expertise. If I present information from a position of authority (Cunningham et al., 2005; Peirce, 1877), students run the risk of becoming *intellectual slaves* who will think and believe what they are told to believe (Moss & Schreiber, 2002). Instead, I want my students to challenge the information I present, including their own thinking and practice. To demonstrate this type of reasoning I must collaboratively design curriculum that fosters and supports inquiry, that nurtures my students into building healthy skepticism and experimentation that could result in the construction of new knowledge.

Figure 5.2. Data was collected and analyzed.

Constructing knowledge through abductive reasoning in the classroom. I intentionally designed the unit of study on climate change to nudge students towards abductive reasoning. Instead of presenting climate change as a set of facts students were expected to memorize, I asked students to find information, wrestle with the information, and reflect on the information, until they came to their own conclusion. While individuals were expected to draw their own conclusion, the community helped generate much knowledge such as through the use of information-seeking questions such as “What is climate change?” and “What is global warming?” As students uncovered climate change information, the information was shared in small groups and as a whole class (Figure 5.3). For instance, as students researched evidence for climate change, each student shared evidence they felt was compelling. This information was then debated and discussed amongst students so that all students could come to understand each piece of evidence from a different perspective.

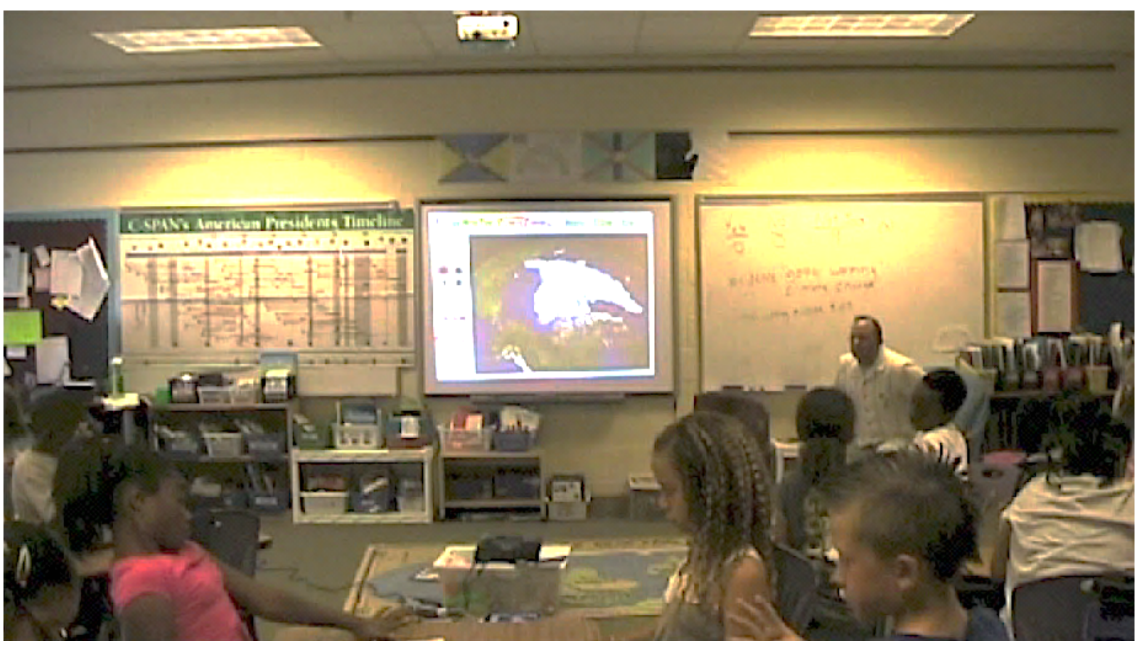

Figure 5.3. Students, as a group, found information, reflected on the evidence, and came to their own conclusions.

With this shared information, we needed a place to collect and reflect on the information. Science journals were used to collect information that was shared in small and whole groups, diagrams were used to make sense of the information, and *I Think I Know…* folders were used to reflect on the information. The science journal, diagram, and *I Think I Know…* provided a place for students to explore and question the information. As an example, when researching greenhouse gases, Alex used his science journal to record the information he found (see Figure 5.4). He defined greenhouse gases

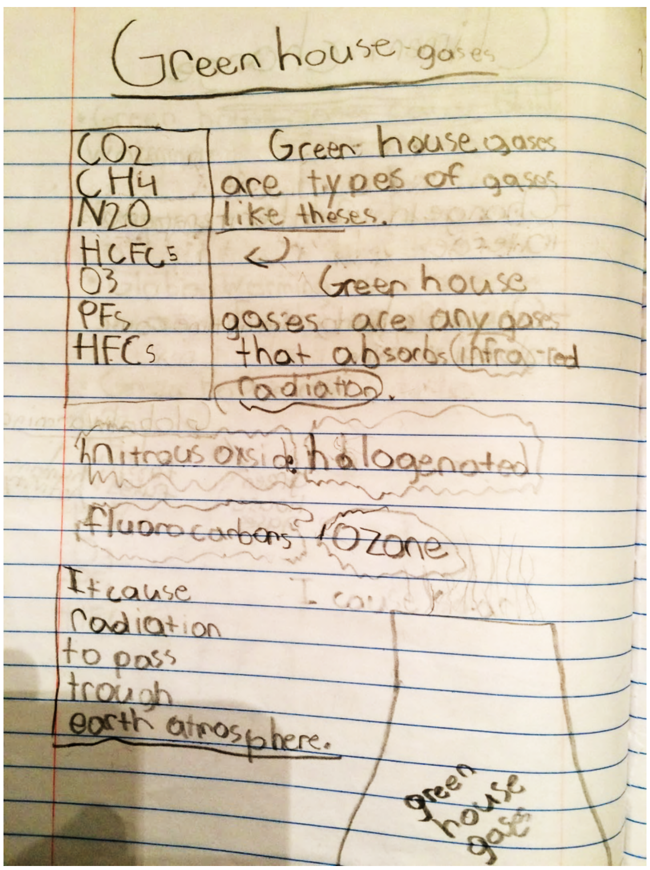

Figure 5.4. Alex recorded information on greenhouse gases in his science journal.

in his own words and included the scientific names for a variety of greenhouse gases. The information in his science journal was used to create his diagram (see Figure 5.5). He used information such the scientific names of greenhouse gases and knowledge of how greenhouse gases are released.

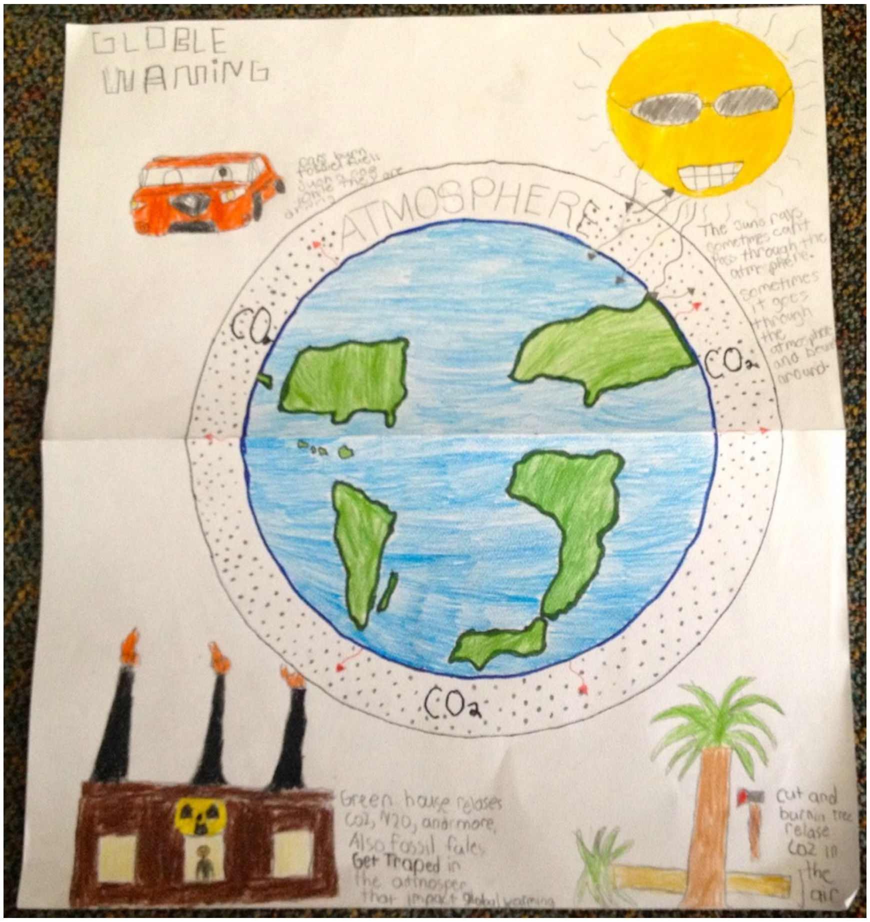

Figure 5.5. Alex's diagram of global warming.

An important part of abductive reasoning is community. When individuals and small groups collected climate change information, it was shared with the whole class. Talk was used to share the information with the group. As students shared, I came to understand that presenting information to the whole class was a self-correcting process. Sharing the information with the group allowed students to refine their ideas and thinking. The class listened, checked their understanding, and clarified misinterpretations of the information.

As an example, Jaci was skeptical of climate change when looking at pictures that supposedly depicted climate change. Two pictures of the same glacier were taken almost one-hundred years apart – one picture was in black and white and the other in color. Her skepticism was based on the black and white picture looking like it was taken in winter and the color picture during the summer. The black and white picture, the one that looks like it was taken in winter, showed a large glacier; the color picture, the one that looks like it was taken in summer, showed melted ice and no glacier. Jaci did not feel the two pictures demonstrated evidence of climate change. Since summers are warmer, the glacier must have melted and came back in the winter. Her comments to the classroom community nudged the class to explore and debate her skepticism. As students shared aloud, Jaci slowly understood the fault in her logic. Listening to the classroom community helped Jaci to check her understanding and refine her thinking.

In the classroom, abductive reasoning did not happen overnight but rather, through a constant state of inquiry. Little by little I introduced new questions that nudged students to seek out information during our climate change unit of study, such as asking "What is climate change?" I asked students to find and gather information on climate change and global warming before I introduced evidence for and against climate change. In this way, students had some background knowledge of climate change and global warming before forming an opinion. Concluding the unit of study by asking students to write a statement of their climate change beliefs meant having to draw upon the evidence they felt was conclusive in order come to their own conclusion. As an example, Beth's statement of belief paper (Appendix H) summed up her beliefs and included evidence she found conclusive. This evidence included pictures of melting glaciers and information from the Bjørn Lomborg video (Lomborg & Timoner, 2011). Hannah (Appendix G) used information she learned through her diagram and included that in her statement of beliefs paper:

> If there is to much CO_2 in the air some of the sun light won't get through you may think that's good but some sun light can get through and the sun light that gets through can't get back out so that heat stays in our atmoshere because all the heat is bouncing off the CO_2 and that's making the earth warm there are also other resons like air conditioning and driving. And that's why I think global warming is caused by humans.

Hannah's new understanding of climate change was constructed as a result of talking about climate change, reifying her understanding of climate change through the creation of a diagram, and reflecting on climate change through the *I Think I Know…* folders. Using this information, Hannah came to her own conclusion concerning climate change as a result of abductively reasoning through the array of information.

Constructing knowledge through talk. Cazden (2001) and Johnston (2004) state that talk is the primary tool used by teachers. With talk teachers "mediate children's activity and experience, and help them make sense of learning, literacy, life, and themselves" (Johnston, 2004, p. 4). At the same time talk is to be used to facilitate the classroom community. Mercer (2002) believes that teachers have a prime responsibility to demonstrate talk as a tool for thinking collectively and collaboratively.

Constructing knowledge through talk in Oregon. Talk profoundly impacted the shaping of our learning experience and facilitated the building of community since it guided our demonstrations and helped community members connect. Because talk was our principle way of communicating, it was also our primary way of constructing knowledge. One of the ways we constructed knowledge was through exploratory talk.

Exploratory talk. Much of the exploratory talk we engaged in took place when community members returned to home base to debrief about the day's experience (see Figure 5.6). Dr. Helmuth and the teachers from the Center for Inquiry gathered

Figure 5.6. Community members engaged in exploratory talk.

around the large dining room table and discussed what we learned in the field and how our new knowledge would potentially impact our classrooms. Our talk explored the need for our students to use authentic tools such as those used by scientists, since inquiring through various tools helps us understand the world in new ways. We discussed different ways of demonstrating to our students the importance of careful and systematic observation such as through scientific sketching. Using exploratory talk in this manner was important because it allowed teachers to try out and sort new ideas, get feedback from other teachers, and to draw on other's knowledge to come to new understandings. Just as important, through the same process of exploratory talk, our conversations facilitated the bonding of individuals and fortified the community of practice.

How constructing knowledge through talk influenced classroom decisions. Mercer and Dawes (2008) state that most talk between teacher and student is asymmetrical meaning that one participant, which is usually the teacher, takes the lead in the conversation by taking control of the conversation. When teachers and administrators visit the Center for Inquiry, they first recognize that talk matters (Mills, 2014) and teachers take a stance towards creating talk that is symmetrical, or talk "in which partners have more equal status and potential for control" (Mercer & Dawes, 2008, p. 1). I have come to understand more and more just how important it is to be cognizant of how I transact with my students through talk since it not only builds community, but also facilitates the construction of knowledge.

Exploratory talk. Exploratory talk was used throughout the day as kids inquired. I valued the spontaneous, unscripted, turn-taking language that erupted through exploratory talk. Barnes (2008) believes, "The readiest way of working on understanding is often through talk, because the flexibility of speech makes it easy for us to try out new ways of arranging what we know" (p. 4). Because of the flexibility of talk, especially exploratory talk in helping students construct knowledge of their world, it was my classroom's first response when making sense of our world. Exploratory talk could be heard throughout the day as students constructed knowledge about circuitry during explorations, used games to add and subtract fractions in math, and debated the issue of slavery during social studies.

For example, while researching greenhouse gases associated with the greenhouse effect, Alexi and Allana were having difficulty making sense of a diagram that illustrated the greenhouse effect:

> A: [reads diagram] that's the sun, the gases are like right here, that some of the heat escapes into the, (inaudible) the atmosphere is right here so then the gases go in and they trap the, here right there, so it goes back to earth
>
> T: Exactly, so you have, you're right, have the sun, the sun [turns the computer]
>
> An: [reads the diagram] Like it escapes, into space, it goes into space and it goes to the, all the way down to the atmosphere. Then the, then the gases into the air and trap heat from the earth so it goes back
>
> T: [pointing to diagram with Allana] So yea, the sun, it warms, it sends its rays to warm, the sun's rays warm the earth, Ok. Some of these rays, they bounce back, so they bounce off the earth, and they go back out. Sometimes they hit the clouds, sometimes these rays hit the clouds, but some heat escapes out into space
>
> Al: and then it goes to space and then it goes all the way to the atmosphere
>
> T: Well, I, I get what you're saying. So some of these rays, you're right, they come down and they bounce up but some of these rays don't go out into space, they get trapped inside here – why?
>
> Al: Because of the atmosphere is, those greenhouse gases trap them.

T: Because those gases that are let out, they cause this blanket, so some of those rays don't leave and they get trapped inside. So some heat trapped by greenhouse gases and they travel back to the earth.

Al: That's why some of the states are the most hottest because of the some of the states like they're, the greenhouse gases are hitting there and it's trapping the heat in so it gets them all the way to 100 degrees

T: but it doesn't do it just over every state, does it?

Al: no it doesn't

T: if it's, if it's a global

Al: all over the world

T: exactly, it's a global warming then it, you're right, does it all over the world.

Al: So if Australia was like 30 degrees one day and the heat got trapped back in the next day it was like 100 degrees

T: Sort of

Al: you would know

A: So the greenhouse, so when the sun (sends it) rays, some of the heat escapes into space which is brought back down to earth because of the greenhouse gases such as carbon dioxide and that kind of thing. Because it releases it so, so it (goes) back down to earth?

Allana, Alexi, and I engaged in exploratory talk to make sense of the diagram. Each person's contribution to the conversation provided a scaffold for the next person to build upon. As the turn-taking continued, little by little it became evident that both students were constructing knowledge until Alexi nicely summed up the diagram.

Information-seeking questions. I did not observe information-seeking questions in Oregon. Lindfors (1999) explains that information-seeking "is project oriented" (p. 38). The Oregon experience was not project oriented, but geared towards helping teachers understand how scientists work while learning about and collecting climate change data. What the Oregon experience did was greatly influence the information I wanted my students to seek.

As I reviewed the data, I noticed the questions I asked framed the information I envisioned to be found. Three information-seeking questions were asked:

1. What is climate change?
2. What is global warming?
3. What is the greenhouse effect?

I made the decision to use these three questions to frame the information I thought students would need in order to develop their own conclusion by the end of the unit of study.

Speaking from the heart. Over time I came to fully appreciate the value of asking my students to speak from the heart when they presented information to their parents during student-led conferences, the class, or in small group. Previously, students shared from pre-written notecards in which they wrote down information they needed to know without taking the information to heart. While this helped students organize the information they would share, over time it became obvious to me that many students were not taking the time to construct knowledge of the material they were sharing. Their language sounded rehearsed and monotone, inauthentic, and on occasion, the language they presented was not their own.

When asked to present their information, speaking from the heart became a metaphor for students taking initiative in constructing knowledge of the material they were asked to share. For example, students found diagrams of either the *greenhouse effect* or *greenhouse gases*, and were asked to share their diagrams with the class. As students were preparing to share their diagrams, Emily and Katie stopped me to ask what the words *radiate* and *re-emit* meant. We went back to their diagrams, looked at how the words were used in the context of their diagrams, and they continue practicing. Eventually, Katie and Emily shared their diagrams to the class:

> K: Diagram 1. The sun, the um, the heat from the sun comes down to the earth and it's absorbed by the at-, absorbed by the atmosphere, which is radiated back to the surface, which means it's, there – radiation, it's like it bounces, and then when it's a, once it's absorbed by the atmosphere it can be either re-emitted up to space or the heat radiated back to the surface which means that if it just bounces that it can go up or it can go down.
>
> E: Diagram 2. The solar radiation passes through the clear atmosphere, that's like, um (inaudible) getting gases from the sun. Most of the radiation is absorbed by the earth's surface and it warms up the earth. Some bounces off and it goes back up into the atmosphere. Some solar radiation is reflected by the earth and the atmosphere. Um, some radiation stays down on the earth which warms the earth's surface.

It was evident Katie and Emily took to heart what they learned from transacting with their diagrams. Words like *radiate* and *re-emit* were used in an authentic manner and correctly used within the context of their diagrams. Speaking from the heart provided a metaphor for Katie and Emily to understand their diagram. Instead of regurgitating information and words such as *radiate* and *re-emit*, I believed Katie and Emily spoke from a place of genuine understanding.

Constructing knowledge through talk in the classroom. Crafton (2007) argues that talk "…is not just a means of communicating content; it is a student's most likely means of accumulating knowledge and sharing it or combining it with personal experience to formulate a personal world view" (p. 517). In other words, talk was used to aid in the construction of new knowledge and for students to demonstrate their current understanding of the world.

Exploratory talk. Exploratory talk was the primary means knowledge was constructed during the unit of study on climate change. It provided the perfect medium for knowledge construction because students and teacher could bounce ideas off of each other, get feedback from peers, and confirm and disconfirm thoughts and ideas (Mercer & Dawes, 2008). As we attempted to define climate change and global warming, we used exploratory talk to grapple with the information. Individual groups used exploratory talk to narrow down and edit information they gathered. As groups shared their definitions aloud, the class engaged in exploratory talk in order to develop a shared definition. Diagrams were used to help students construct knowledge of the greenhouse effect. As we attempted to make sense of these diagrams (see Figure 5.7), I made it clear that making sense of these diagrams would rely heavily on talk. A critical incident in helping me understand the importance and value of engaging in exploratory talk with my students took place when I worked alongside Allana and Alexi (see Appendix F for transcription of our conversation). During this conversation, Allana, Alexi, and I used the power of talk to make sense of a diagram and thus, come to a deeper understanding of the greenhouse effect. The turn-taking structure of this type of talk allowed each participant in the conversation to build upon each other's comment and to slowly develop a deeper understanding of the topic. For instance, once Allana and Alexi realized two pieces of information were talking about the same thing, they began to talk through their understanding of the diagram:

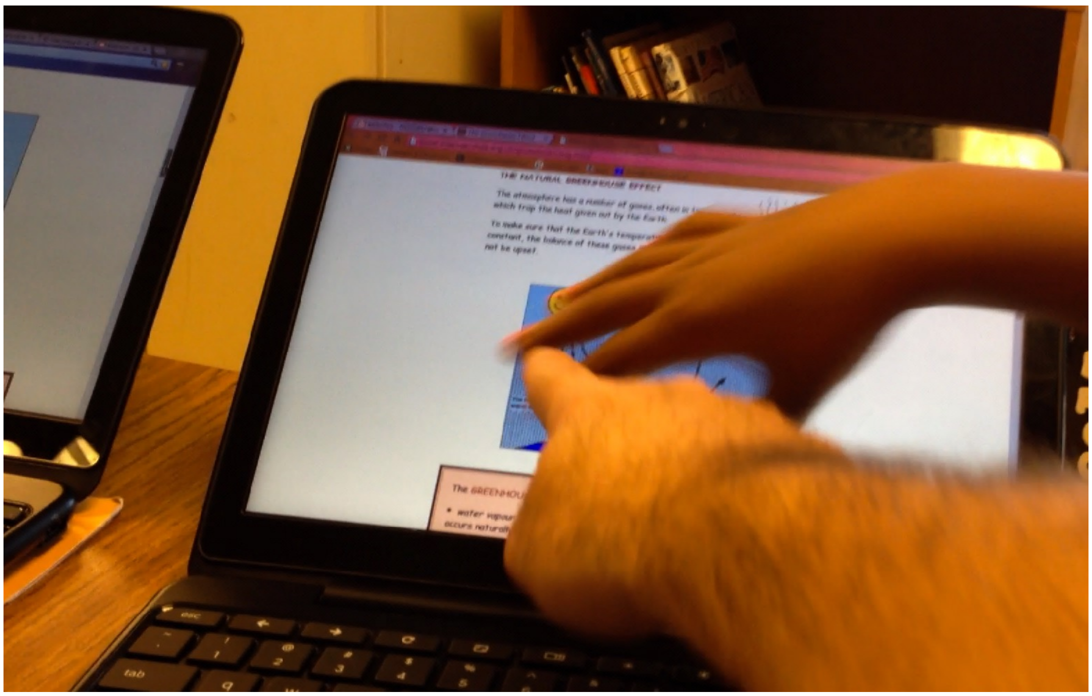

Figure 5.7. Talk was used to construct knowledge of diagrams.

> T: …but they're both, but they're both talking about gases, atmosphere, and trapping in heat. And this is, and actually this is the picture that Maria even showed me and she used that picture as a description of it so read that picture right there, read that diagram
>
> A: [reads diagram] that's the sun, the gases are like right here, that some of the heat escapes into the, [inaudible] the atmosphere is right here so then the gases go in and they trap the hear right there so it goes back to earth

T: Exactly, so you have, you're right, have the sun, the sun [turns the computer]

Al: [reads the diagram] Like it escapes, into space, it goes into space and it goes to the, all the way down to the atmosphere. Then the, then the gases into the air and trap heat from the earth so it goes back

T: [pointing to diagram with Allana] So yea, the sun, it warms, it sends its rays to warm, the sun's rays warm the earth, Ok. Some of these rays, they bounce back, so they bounce off the earth, and they go back out. Sometimes they hit the clouds, sometimes these rays hit the clouds, but some heat escapes out into space

Al: and then it goes to space and then it goes all the way to the atmosphere

Engaging in exploratory talk meant not handing out answers like candy on Halloween, but to engage students in collective thought. There were no lesson plans that directed our talk. My job was to apprentice students in collective thinking, as well as nudge students to transform our collective thought into personal interpretation of our shared experience (Mercer, 2002).

Information-seeking questions. Wells (2001a) states when teachers create curriculum, decontextualized knowledge should never be an option. Instead, "…problems and questions that are likely to be of significance to students as they try to understand and act effectively and responsibly in the world that they inherit from previous generations" (Wells, 2001a, p. 181) should be the norm. I intentionally used information-seeking questions (Lindfors, 1999) to nudge students to take active and reflective roles in constructing knowledge. As an example, I used information-seeking questions such as "What is global warming?" Asking this particular information-seeking question framed the type of information students uncovered. Students had to find specific information to answer the question while some information was put to the side.

When I framed inquiry in this manner, the question shaped the goal and direction of the inquiry, and the kind of information they were to find and use. As students were sent out on their own or in small groups, the expectation was they would inquire into this question. They used the internet, texts, and/or diagrams to engage in reflective thought with the materials. Then they used talk to share the information they found and explore it with another individual.

Speaking from the heart. One way students demonstrated their understanding of climate change by speaking from the heart. When student shared their understanding of a particular topic through talk, usually without the use of notes or notecards, they spoke from the heart. For example, after completing their diagram of climate change, Alexi and Jeena used their diagrams to speak from the heart as they shared their understanding of climate change (Appendix J):

> J: This is the atmosphere and in the atmosphere is CFC, CO_2, ozone, methane, HFCs, and H_2O
>
> T: and H_2O is not really water up in the air, it's what, it's water …
>
> A: it's water molecules
>
> T: water vapor
>
> A: This is, this is the sun and the sun sends its sun rays (inaudible) make it to the atmosphere and then bounce off the atmosphere and some make it through and then when it hits it here it sends off its own rays called the infrared rays and some infrared rays try to leave and they have to go back down to earth

J: and this is deforestation, which um, when people cut down the trees, it releases carbon into the air.

A: Um, this is human activity. What human activity really is, is what humans are doing to make the earth warmer

T: And what are they doing to make the earth warmer?

A: Their like, using a lot of electronics and burning fossil fuels.

T: Ok. Cause' the fossil fuels do what?

A: The fossil, the fossil fuels like coal, coal and (inaudible) and natural gas, when it burns the fossil fuels it builds up inside the earth's (inaudible)

T: But it increases what? What specifically?

A: It increases the level of CO_2

T: CO_2, CO_2, which is a greenhouse gas, right?

A: Which (inaudible) cuts down trees and releases carbon dioxide, carbon dioxide into the air.

J: And in the car, the cars burn fossil fuels which releases carbon into the air.

A: And then for the buildings, then it just explains, like for fossil fuels like carbon gas, coal, coal, and natural gas which (inaudible). In big ol' factories they burn a lot of them everyday and so, like coal, the coal comes and burns it all up, so

While their diagram reified their understanding of climate change, sharing their diagram by speaking from the heart provided a window into Alexi's and Jeena's understanding of climate change. Speaking from the heart allowed Alexi and Jeena to verbally express the knowledge they constructed and internalized.

Constructing knowledge through transmediation. Transmediation is the act of translating meaning in one system to another sign system (Berghoff, Borgman, & Parr, 2003; Cowan & Albers, 2006). As an example, dance, poetry, mathematics, and art are all considered sign systems in which humans create and express meaning with other people. Learners do not simply translate meaning but transform their understanding of a sign system into another sign system. It is in this transformation that students construct new understandings as they link new information with old information.

Constructing knowledge through transmediation in Oregon. Dr. Helmuth used a variety of tools that helped him inquire into climate change. One tool used was a small, laptop computer outfitted with sensors. These sensors were designed to read the stress levels of mussels in the intertidal zone (Figure 5.8). When the sensor was placed inside

Figure 5.8. The way data was expressed was translated between sign systems.

the mussel, it read the stress levels of the mussels and a large quantity of numbers, lines, and other signs appear on the computer screen. To the average user, unless they have experience working with this particular software, the signs on the screen represented gibberish. To Dr. Helmuth and his colleagues, they were able to make meaning from the signs represented on the screen. In order to make the data meaningful for others, graphs, charts, or diagrams would have to be created.

How constructing knowledge through transmediation influenced classroom decisions. When I observed Maria using diagrams to make sense of the greenhouse effect, and Allana, Alexi, and Mary constructing knowledge of their diagram through exploratory talk, I truly began to understand the potential diagrams have for helping my students make sense of their world.

I asked students to create diagrams, charts, and other visual representations in a variety of subject areas such as math (solve a math problem in a variety of ways), science (explain the water cycle), social studies (compare Articles of Confederation to the Constitution), and reading (graphing the tension of a story). Transmediation through diagrams and charts allowed me to see connections and relationships between what we studied and student understanding. I also came to understand that students need opportunities to build and construct models and diagrams; not just interpret them. Just like drawing helps us to slow down and notice important details about writing (daSilva, 2001), building and constructing models helps students to slow down and notice things about the topic under investigation.

Constructing knowledge through transmediation in the classroom. Using this newfound understanding of diagrams pushed me to intentionally have students make sense of and create diagrams on climate change (Figure 5.9). Students transacted with a variety of climate change diagrams to help them better understand the signs and symbols used to represent features of climate change and global warming. While some of the signs represented the same meanings as the diagrams they read online, students often translated those signs in a manner meaningful to them, then represented those signs in a personal manner. Once completed, students' diagrams became a metaphorical placeholder that contained their represented thinking and understanding of climate change.

Figure 5.9. Students used a variety of signs and symbols to represent knowledge meaningful to them.

For example, while some students like Hannah and Marissa created their diagram using signs and symbols found in a variety of the diagrams the class looked at online (see Figure 5.10), Beth, Maria, and Mary's diagram took a different approach. Their diagram included a variety of flaps that when opened, revealed information on global warming (see Figure 5.11). While there was a larger flap that contained a diagram of global warming, the other flaps included specific information such as CO_2, deforestation, and fossil fuels. These flaps represented their understanding learned as a result of our unit of study on climate change.

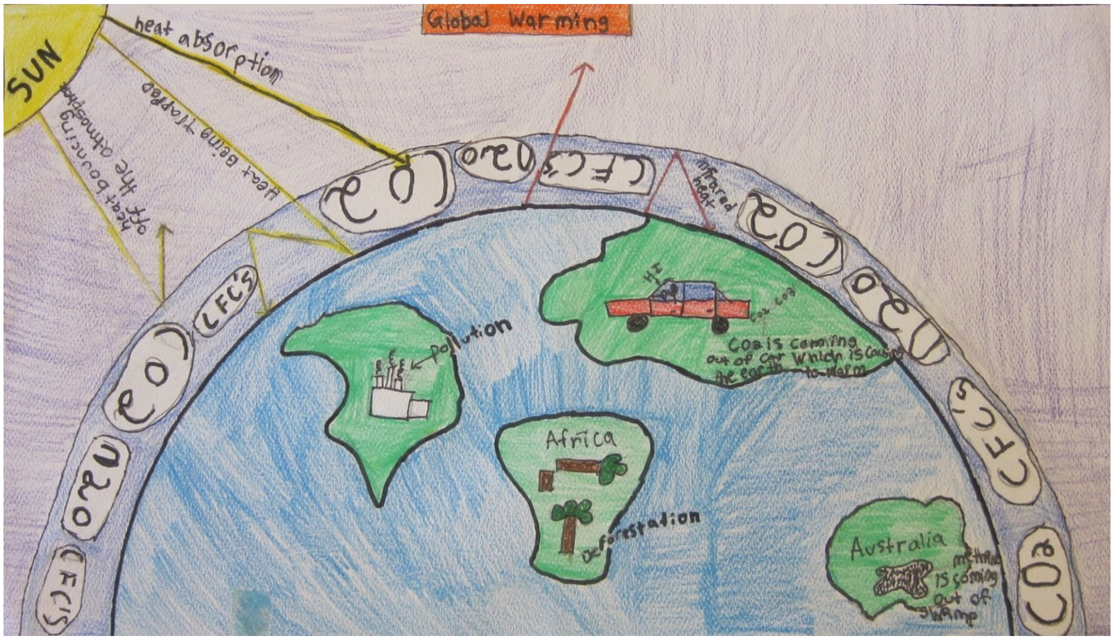

Figure 5.10. Hannah and Marissa's diagram.

My new understanding of how transmediation fostered knowledge construction nudged me to envision other ways students could express meaning across sign systems. As an example, as part of our South Carolina state standards my classroom studied

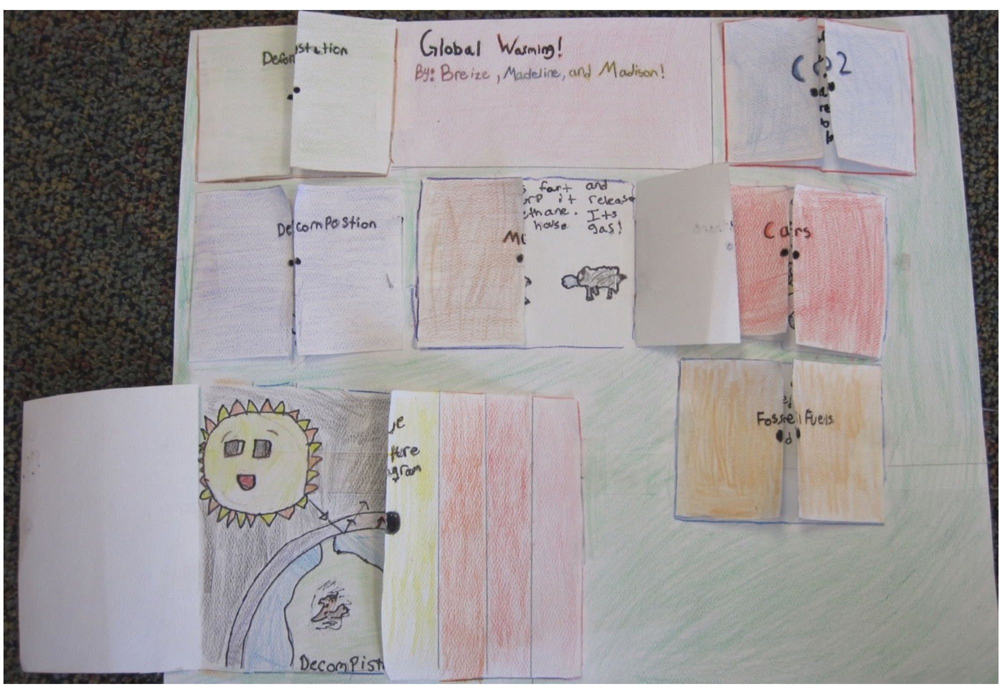

Figure 5.11. Beth, Maria, and Mary's diagram.

geologic landforms of the ocean floor. We spent several weeks learning about these features and comparing them to landforms found on land. To demonstrate their understanding, I asked students to reify their understanding of underwater landforms using Legos. Once students created their models, they used Educreations (Educreations, 2015), an iPad app that creates video tutorials, to record a tutorial that explained the landforms in their model (see Figure 5.12). Underwater geologic features were divided amongst each student in their small group. Each student contributed to the tutorials by labeling each landform and recording their voice which defined each landform.

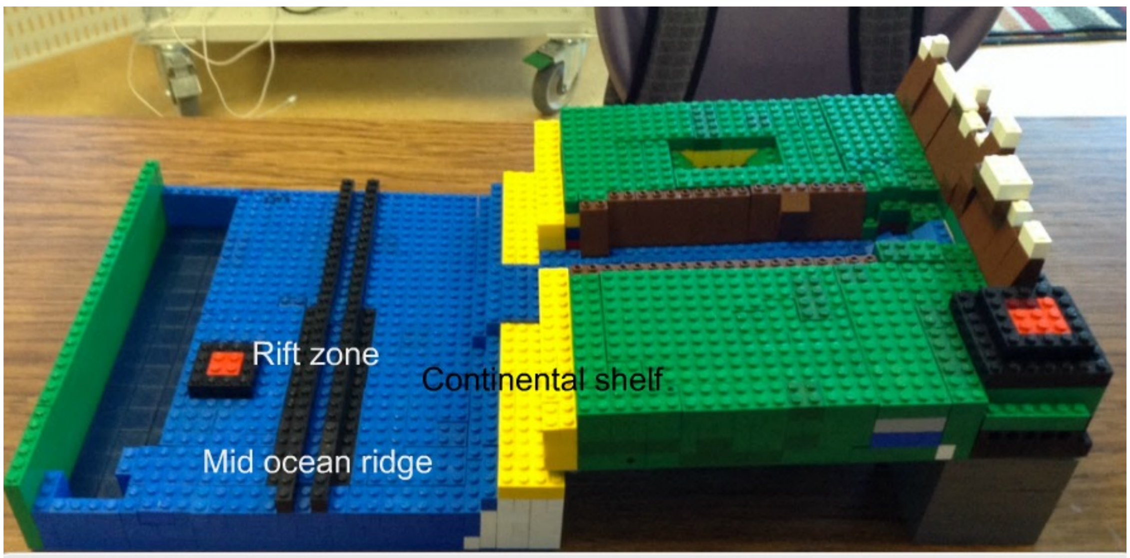

Figure 5.12. Students constructed ocean landforms using Legos.

Constructing knowledge by building upon prior knowledge and experience. Researchers have come to the conclusion that new knowledge is constructed when learners connect new ideas, thoughts, and understandings to their prior understanding of a particular topic or idea (Barnes, 2008; Lave & Wenger, 1991; Wells, 1986; Wells, 1999; Wenger, 1998). Learning is never passive as students are constantly attempting to make sense of new information, as they reorganize prior understanding in light of the new information. In this manner, the learner is in a constant state of constructing knowledge (Barnes, 2008).

Constructing knowledge by building upon prior knowledge and experience in Oregon. Since four of the teachers previously traveled to the Oregon coast with Dr. Helmuth and his colleagues, there were four sets of knowledge Dr. Helmuth could tap into. Those teachers had prior experience using many of the tools, and Dr. Helmuth could tap into those teacher's prior experience of using those tools to collect data.

As an example, this was Tammy Vice's second trip to the Oregon coast with Dr. Helmuth. She had previous knowledge of how to work a special laser level that could determine height from sea level (see Figure 5.13). Tammy was apprehensive using the

Figure 5.13. Dr. Helmuth helped Tammy use the laser level.

laser level since she had not used it in over a year. In order to help Tammy feel more comfortable, Dr. Helmuth reminded her that she used this tool last year. Little by little he re-introduced her to the various parts of the laser level. You could see Tammy relaxing as Dr. Helmuth demonstrated how to hold the laser level. In the midst of that demonstration Tammy was observing. Eventually, she pitched in as Dr. Helmuth and Tammy's talk flowed back and forth in a turn-taking manner. In a manner of minutes, through Dr. Helmuth and Tammy's talk, and his demonstrations, Tammy slowly remembered how to use the laser level. Her knowledge was solidified as she put into practice what she remembered and over time, Tammy independently took over the task.

How constructing knowledge by building upon prior knowledge and experience influenced classroom decisions. Barnes (2008) believes when children have difficulty understanding, it is usually because new information has found no place to connect with existing schema and is quickly forgotten. He continues to state that, "Since we learn by relating new ideas and ways of thinking to our existing view of the world, all new learning must depend on what a learner already knows" (Barnes, 2008, p. 3). I intentionally highlighted each lesson by linking what we *will* be learning with what we *have* studied. Though I believe students naturally attempt to make connections in their learning, I do this so that as we are learning a particular topic, students are intentionally trying to connect new information with prior knowledge and experience.

In order to provide experiences in which I could build upon my student's prior knowledge and experience, it was important I understood their funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992) which refer to the "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (Moll, Amanti, Neff, & Gonzalez, 2005, p. 72). Knowing my students' social, cultural, and educational knowledge inside and outside the classroom, helped me to explicitly make connections between what they already knew and what we were learning. For instance, many of my students created their own businesses – two children had a cupcake business, another child had a dessert business, and three other children had a Frappuccino business. Knowing I had many entrepreneurs opened opportunities to explore math concepts that directly related to their businesses, such as fractions, percentages, and decimals.

Knowing my students' funds of knowledge, combined with what I know about their school life, opened opportunities to explicitly make connections between their prior knowledge and new information. As I attentively listened to my students, and engaged in exploratory talk, I intentionally tried to create metaphors so that my students could gain a better grasp of a particular concept such as comparing the greenhouse effect to being trapped inside a car with the windows up.

Constructing knowledge by building upon prior knowledge and experience in the classroom. Jumping straight into a unit of study on climate change in the midst of the school year seemed contrived and inauthentic. Since the study of weather was a part of our South Carolina state standards, starting the unit of study with weather seemed an excellent transition point into climate change. We could rely on our understanding of weather to help us construct knowledge of climate change since the two areas are related.

Metaphor. As I combed the data, I came to realize that students and I used metaphor as a means of understanding new concepts. Lakoff and Johnson (2003) define metaphor as "understanding and experiencing one kind of thing in terms of another" (p.

5). Thus, to create metaphor, one needs to compare or contrast their prior understanding and/or experience of a particular thing with a new experience. As an example, when Allana, Alexi, Mary, and I were discussing a diagram, I created the metaphor of being locked inside a car with the windows up. All three students mentioned the car would be hot inside because the heat is trapped. Alexi builds upon my metaphor with a metaphor of her own:

> Al: I have another, I have something else. Cause like, when it was hot before, before it go, well there is two different points cause in the summer time, the car, when you get in the car, like if you are getting picked up or something, like when I go out it's really hot because it's been sitting, because it's sitting there all day and if, even, even if you have the windows closed that just traps more heat inside, it traps the heat that was already in the car, inside the car, and then like, if it's on a winter day it would be less cold because, um, it still traps the heat.

In Alexi's metaphor she used the same car analogy to talk about how leaving your car windows up in the summer and/or winter can cause the inside of the car to heat up. The metaphor was used to explain that global warming is not a hot weather phenomenon only experienced in the summer time, but a yearlong weather phenomenon since no matter the season, the temperature will remain slightly above the normal temperature. Thus, because more hot air is being trapped in the atmosphere due to greenhouse gases, temperatures will always be warmer than average whether it is summer or winter.

As students created diagrams to demonstrate their understanding of climate change and global warming, I noticed they began using metaphors to grow and explain the knowledge they were constructing across sign systems. They demonstrated how constructing models promoted metaphorical thinking. For instance, when Hannah shared her understanding of global warming, she talked about the meaning of the signs used in her diagram (see Figure 5.14). She created a dark blue band that surrounded the Earth, which represented the atmosphere. Inside this band, Hannah created bubbles containing the scientific names for some of the greenhouse gases. The largest bubbles represented CO_2 because it is the most common greenhouse gas. Hannah's group also used pictures to metaphorically represent causes of the greenhouse effect such as cut trees which represented deforestation.

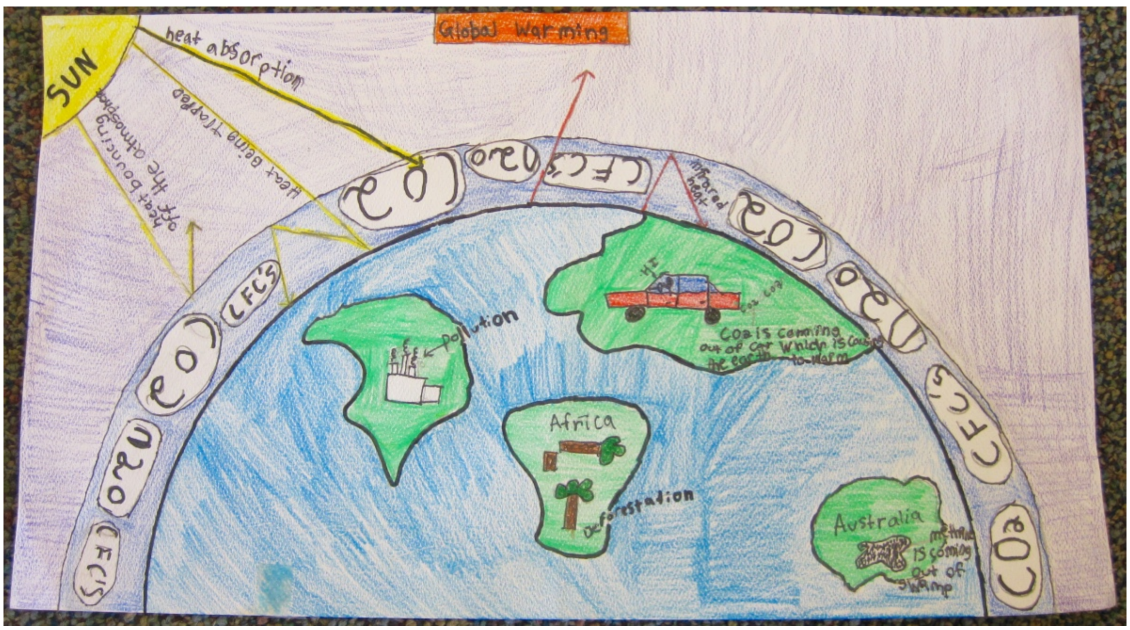

Figure 5.14. Metaphor was embedded within Hannah's diagram.

Constructing knowledge through observing and pitching in. Observing and pitching in was an important feature of an apprenticeship model as portrayed in chapter 4. It also emerged as a dominant pattern when analyzing knowledge construction across both contexts. Dewey (1923) stated that constructing knowledge is best achieved, "Through the senses, or by apprenticeship in some form of doing" (p. 338). While Dewey described this as *learning by doing*, Paradise and Rogoff (2009) describe learning through observing and pitching in as learning that takes place within family and community-based settings. Observing and pitching in is important in maintaining the community through everyday activities that are vital to that community's existence. In Oregon and the classroom, these communities could only exist through the contributions of its members.

Constructing knowledge through observing and pitching in in Oregon. Much of the learning that took place in Oregon happened through Dr. Helmuth and his colleague's many demonstrations. In the midst of these demonstrations, teachers from the Center for Inquiry were expected to observe and pitch in as a means of participating in the everyday activities of the community. One of the ways we participated in the everyday activities of the community was by learning to use the tools of the community. This meant learning to use the gigapan.

Tim and I gathered around Dr. Helmuth as he demonstrated how to use the gigapan (see Figure 5.15). He talked in depth about the settings on the camera and shared what he learned since he purchased the camera. Dr. Helmuth showed us the settings on the gigapan and demonstrated the appropriate settings needed for the type of pictures he was taking. He shared that he had new software that would allow him to make these gigapan pictures interactive. Tim and I observed as Dr. Helmuth talked. We asked a variety of question. Each question we asked nudged him to show us another feature of the gigapan. Eventually, Dr. Helmuth stepped aside and said, "Hey, one of you guys go ahead and do this." Tim stepped in and starting pitching in. As Tim adjusted the settings he would ask Dr. Helmuth questions. Instead of providing the answer, Dr. Helmuth talked with us about what he was trying to achieve and asked for our opinion. All three of us talked and adjusted the settings based on the conclusion the three of us reached. As Tim continued to pitch in, we learned to use the gigapan through Dr. Helmuth's demonstrations, our observations with the aid of our talk, and pitched in when appropriate.

Figure 5.15. Dr. Helmuth demonstrated how to use the gigapan.

How constructing knowledge through observing and pitching in influenced classroom decisions. Paradise and Rogoff (2009) believe that "Children everywhere learn by observing and listening in on activities of adults and other children" (p. 176). While Paradise and Rogoff state that *children* learn through observing and listening-in, I believe this can be expanded to anyone who positions themselves as a learner. Teachers from the Center for Inquiry demonstrated this as they apprenticed themselves under Dr. Helmuth.

Observing and pitching in became a general term for organizing lessons that encouraged students' active participation. Instead of focusing completely on content, I organized lessons so that students were learning through active participation in the engagement. For instance, as students worked in groups to order fractions from least to greatest, they listened to one another, asked questions, and made suggestions. In the midst of ordering fractions, students grabbed fraction cards and arranged them so they could be compared. Students talked as they compared the fractions, as they arranged them in order.

At the same time, observing and pitching in meant students contributed and sustained the classroom community. Through their participation in the classroom community's everyday practices, students felt a sense of belonging and ownership when they contributed. This was especially evident when students contributed to the classroom community through classroom jobs such as line leader and librarian.

Constructing knowledge through observing and pitching in the classroom. I came to value the active construction of knowledge as a way students were observing and pitching in. To construct knowledge, students must be actively observant of the materials and individuals they transacted with. They must participate in classroom life as they uncovered information. I placed a greater amount of responsibility for the construction of knowledge in my student's hands through observation and pitching in. When my students saw the relevance of their work, they understood they were contributing to the needs of the classroom community.

When I mentioned to Brandon that his use of the gigapan would contribute to our understanding of climate change, he was excited to help out. To help him understand how to use the gigapan, it was necessary for both of us to work collaboratively – Brandon would observe and pitch in and as I provided demonstrations (Paradise & Rogoff, 2009). As I demonstrated how to use the gigapan, he intently observed my actions; when he lacked understanding, he asked questions; when he felt comfortable he pitched in. Brandon was actively engaged in the task, acquiring the knowledge he would need to independently perform the task. He pitched in by setting up the tripod, attached the gigapan to the tripod and leveled it, and adjusted the settings on the gigapan. Brandon displayed his knowledge through his actions. Later, the knowledge he gained was put to the test as he apprenticed Charles into using the gigapan.

Constructing knowledge through reflection. Reflective practice and inquiry go hand in hand. In fact, Mills (2014) states, "It's the process that holds all the other processes together and helps us move forward by looking back" (p. 79). This is why I weave reflection into all curricular structures. Students need opportunities to reflect before, in the midst, and after the lesson to reinforce learning. Regular reflection means students "reflect on what worked, and what didn't, and celebrate their accomplishments" (Mills, 2014, p. 80). Reflection is transformational since it is how experience is turned into learning. Thus, new knowledge is constructed when new experiences connect to prior knowledge.

Constructing knowledge through reflection in Oregon. Since the intertidal zone is an ever-changing environment, Dr. Helmuth and his colleagues engaged in constant reflection. They continually evaluated the situation and made spontaneous decisions that were based on years of experience in the field. There was one example of Dr. Helmuth's reflection that sticks out more than others.

It started to rain after thirty to forty-five minutes on our first day of working in the intertidal zone. Data collection instruments were packed and everyone headed to the parking lot. At the top of the cliff, Dr. Helmuth turned around and looked across the entire beach. He stood there pondering the situation, in the rain, and reflected. Dr. Helmuth made some comments about science not always being systematic and organized because things happen in the field that can keep scientists from collecting their intended data. He mentioned that scientists sometimes have to improvise and develop an alternative plan in order to work around inconsistencies. The opportunity to reflect seemed to allow Dr. Helmuth to slow down and assess the situation. Because of the rain, we could no longer use most of the tools. No matter, Dr. Helmuth understood there were other ways for us to collect data. He developed another plan, talked over these plans with his colleagues, and we headed back down the cliff to continue working. Reflecting on the situation, I wrote the following comments in my field journal:

> *Brian, he, while he, was set on doing certain experiments, he had to improvise, the rain, we packed up…lets go back out there, what else can we do, lets improvise, lets still make this a meaningful experience, let still come to some understanding about why we're doing this, always something that we can go out there, we may not have the tools that we have, but we can always come out here and learn in some other manner about something else, we can come to some understanding in some other way besides the tools we had set out to use, um, and so that was really interesting and he was so calm about it…* (Field Journal – 6/5/12)

How constructing knowledge through reflection influenced classroom decisions. Dr. Helmuth demonstrated that reflection was a natural extension of positioning oneself as an inquirer – to inquire meant to be reflective. During the unit of study on climate change, when I felt students lacked understanding, I slowed down, reflected on the situation, and approached the lesson from an alternate perspective. Sometimes this meant letting go of a planned lesson, finding a different book or video to illustrate a point better, or finding a colleague for advice. During the unit of study, responding to my student's needs through reflection was at the heart of helping students construct knowledge.

Historically, when I asked students to reflect, writing in a journal was the primary means. After students independently read, I asked them to reflect on what they read; after a science experiment I asked students to reflect on the demonstration. I viewed reflection as something that happens after the fact – almost as a means of summarizing the lesson and bringing closure to it. While this reflection is notable, it is not sufficient.

I came to understand that students needed opportunities to engage in reflection before and in the midst of the lesson. By reflecting before the unit of study on climate change, students accessed their current understanding and brought it to the forefront. Students also needed opportunities to slow down and reflect on what they understood in the midst of the unit of study on climate change. This was important so that students could transform experience into learning.

Constructing knowledge through reflection in the classroom. My work with *I Think I Know…* folders and diagrams nudged me to revalue reflection as a means of helping students construct knowledge. We started using the *I Think I Know…* folders as a way of beginning our unit of study on climate change so I could get a sense of students' prior understanding (see Figure 5.16). The first day we used these folders, I asked students to reflect on their prior knowledge of climate change. This information was written on sticky notes and placed on the *I Think I Know…* section of their folder. These first sticky notes acted as a placeholder for students' initial understanding. Over time, as students constructed knowledge of climate change, they could see by the placement of their sticky notes how their understanding changed over time.

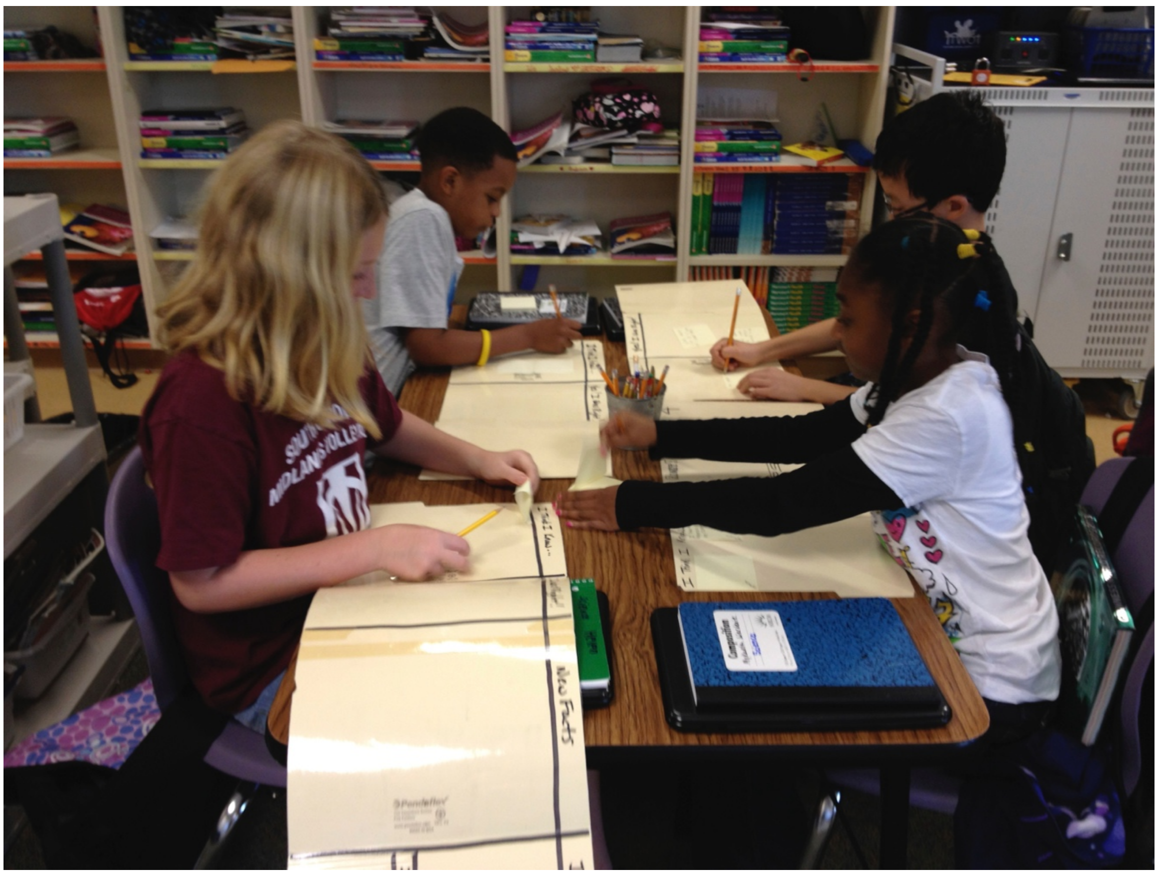

Figure 5.16. I Think I Know... folders documented students' prior knowledge.

For example, when the class first started to use the *I Think I Know…* folders, their initial sticky notes represented their prior knowledge or what they thought they understood about climate change. These sticky notes fit onto the *I Think I Know…* section of their folder. As prior information was verified and knowledge was constructed, this information, recorded on sticky notes, was placed onto the other areas of the *I Think I Know…* folder. Alex's folder contained sticky notes located on several areas of his *I Think I Know…* folder (see Figure 5.17). While some prior understandings remained in the *I Think I Know…* section of his folder, one piece of information was moved to the *Yes! I Was Right!* section (e.g., "climate change does change weather"), while new knowledge gained during our study was placed in the *New Facts* section of his folder (see Appendix J for transcription of folder). Questions that were unanswered remained in the *I Wonder* section (e.g., "Is climate change good or bad).

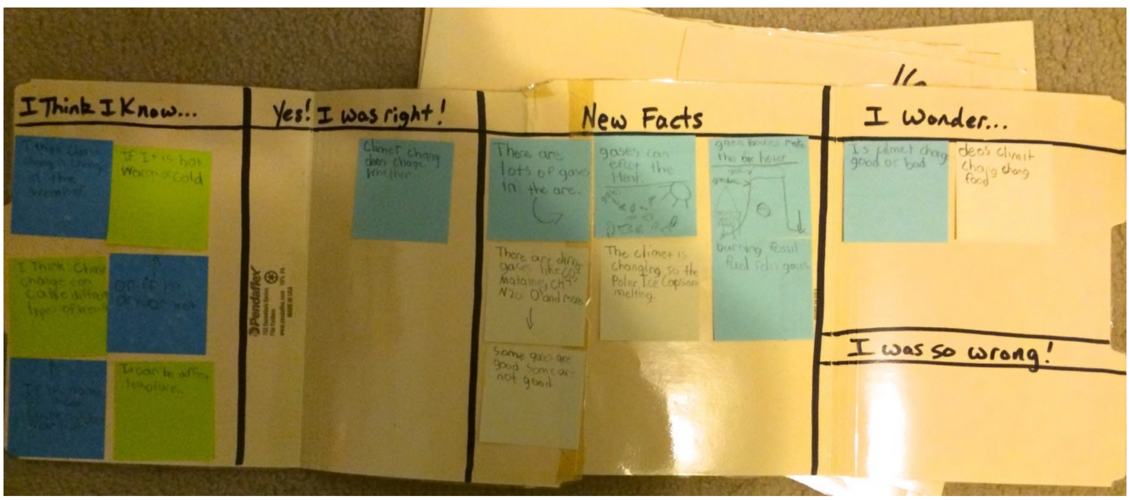

Figure 5.17. Alex's *I Think I Know...* folder.

The *I Think I Know…* folders also helped me attend to students' needs as learners. Looking over their shoulder in the midst of their reflection guided my next steps in the lesson; reflecting on their journals after the lesson helped me plan future lessons.

The true power of reflection became evident when I asked students to create diagrams (see Figure 5.18). I came to understand that having students create diagrams, then verbally share their understanding through the diagrams, parallels the idea of having students draw pictures before writing. Karen Ernst DaSilva (2001) believes that drawing is an excellent form of preparing children to write because “it helps us know our subjects and our thinking and encourages us to dig in” (p. 3). Drawing helps the child to slow down (daSilva, 2001) and reflect on what they would like to put into words. This became evident after watching a video clip of Susan Bolte’s kindergarten classroom. Susan Bolte asked students to engage in the act of bubble blowing so later, they could reflect on the experience, talk about the experience, then write about the experience, from the perspective of participants in the experience.

Figure 5.18. Student created diagrams of global warming.

Once students finished their diagrams, I asked them to speak from the heart as they reflected on their diagram. In my classroom, Jeena and Alexi reflected on their diagram to explain their understanding of the greenhouse effect (see Figure 5.19). As they shared, they pointed to several features and shared what the various signs and symbols represented (Appendix K). For example, as Jeena pointed to different greenhouse gases, she shared:

> J: This is the atmosphere and in the atmosphere is CFC, CO_2, ozone, methane, HFCs, and H_2O.

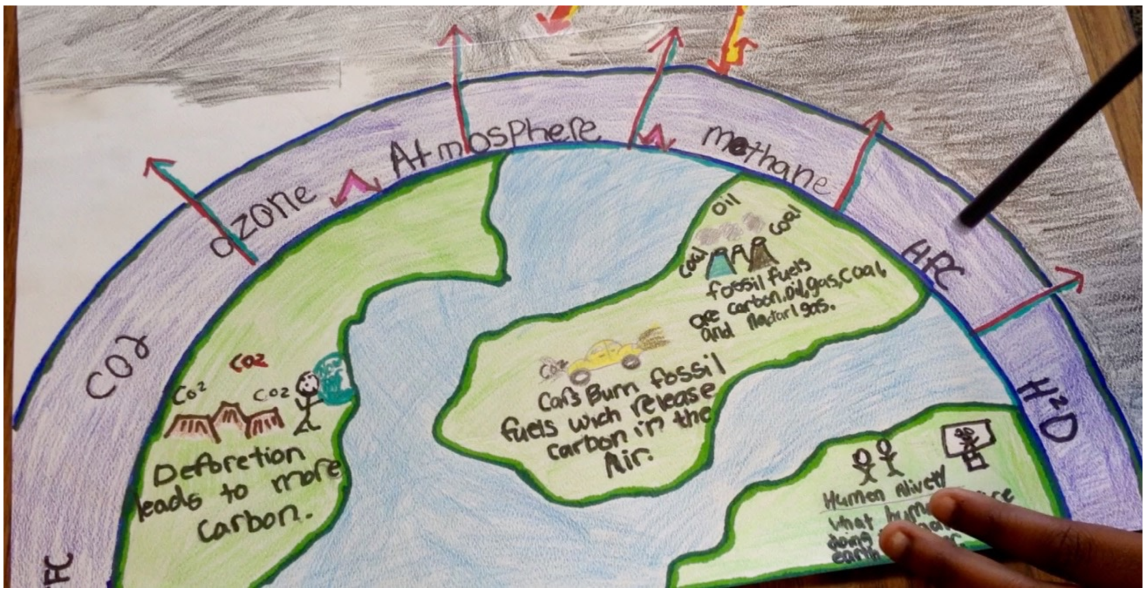

Figure 5.19. Jeena and Alexi reflected on their diagram as they used talk to demonstrate their understanding.

When Alexi shared, she pointed to the sun and explained how the arrows represented the sun's rays:

> A: This is, this is the sun and the sun sends its sun rays (inaudible) make it to the atmosphere and then bounce off the atmosphere and some make it through and then when it hits it here it sends off its own rays called the infrared rays and some infrared rays try to leave and they have to go back down to earth

Constructing knowledge through purpose and investment. Purpose and investment proved to be vital to my understanding of an apprenticeship model as illustrated in chapter 4. Purpose and investment emerged as a dominant pattern for a second time as I analyzed how knowledge was constructed in Oregon and my classroom. *The Project Approach*, an advocacy group known for promoting project based learning, stated that a "Student's disposition to learning is strengthened by a corporate sense of purpose" (A Sense of Purpose, 2014). Dr. Helmuth made it clear the purpose of our work in Oregon would be to collect climate change data that would be used by his lab and the international community. He helped teachers from the Center for Inquiry understand the purpose of the work by engaging them in the same tasks marine biologists engaged in. This corporate sense of purpose, of the community working towards a common goal, helped us become invested in our work - we wanted to work because we understood our work would be used for real purposes. The more we were invested, the deeper our understanding of the work. Thus, we constructed knowledge as a result of understanding the purpose of our work and our level of investment.

Constructing knowledge through purpose and investment in Oregon. One reason the purpose of our work led to our investment was through the use of the tools we used. Teachers from the Center for Inquiry used a variety of tools to collect a range of data. Using the same tools Dr. Helmuth and his colleagues used provided a sense of purpose. We used tools such as levels to measure the height of pisasters from sea level, measuring tapes to create a transect of the area pisasters were being measured, rulers for measuring the arms of pisasters, and journals for recording data (see Figure 5.20). While in the intertidal zone, we also wore the same clothing Dr. Helmuth and his colleagues wore. Clothing consisted of rubber waders, weatherproof jackets, and boots to keep us dry while working in the wet conditions. Tim O'Keefe felt the authenticity of our work contributed to the purpose of our trip when he stated, “the opportunity to work with scientists in a meaningful way gave true purpose to our learning experience…we learned and participated alongside scientists, collecting the same authentic data they were collecting...” (personal communication, Nov. 11, 2013).

Figure 5.20. Authenticity of our work provided purpose.

The purpose of our work immediately led to the teachers from the Center for Inquiry feeling invested. On our first day in the intertidal zone, it started to rain. We packed up our gear and headed toward the cars. Dr. Helmuth developed an alternate plan to continue working in spite of the rain – a plan all participants joyfully agreed to. I recorded the following notes in my field journal concerning the level of investment felt by all participants in the Oregon experience:

> they [CFI teachers] all understand that this is [an] opportunity to expand their understanding of the world…and that is more important than going back and drinking some coffee and eating [a] danish, that seeking of knowledge is more important than being comfortable in a warm car…having opportunities such as this come around so seldom, that you gravitate, you hold on to it, and you love it, and you crave it and you care for it because you know that it's going to be, uh, knowledge and expanding of your understanding of the world (Field Journal – 6/2/12)

When there was authenticity in the work, all participants were invested in their work. This investment led to a deeper understanding of the data that was collected, the tools used to collect the data, how scientists work in the field, climate change, and the Oregon experience as a whole.

How constructing knowledge through purpose and investment influenced classroom decisions. I have come to believe that when students see the purpose in their work, they are often invested, which leads to deeper understanding. Based on my work in Oregon, I wanted to create an approximate experience for my students in which they would collect data that would be used by scientists from around the world, to help them understand climate change. I found this experience through the work of citizen science.

My students participated in a citizen science project through the United States of America National Phenology Network (USA-NPN). Our job was to observe a plant's phenology – the key seasonal changes in regards to weather and climate, which take place from year to year such as the changing of leaf colors, flowering, and the growth of fruit. The first plant we observed was a cloned dogwood tree. By observing a plant that was genetically identical, scientists knew with confidence that the timing of phenological events between cloned dogwoods is based on local environmental conditions (dogwoods, n.d.). We created a schedule to record our observations. When the cloned dogwood arrived, it was still a young sapling so students decided to add another tree to our observations – a persimmon tree growing wild on the recess field.

Making phenological observations of the two trees nudged students to take active roles in coming to understand the role phenology has in understanding climate change. For example, during our unit of study on climate change, students brought up phenological information when we looked at evidence for climate change. Our classroom found pictures of the famous cherry trees located in Washington D.C. Under the picture was a caption that stated the cherry trees were blooming an average of five days latter than normal due to global warming. Students did not feel this was alarming evidence showing global warming since a multitude of environmental conditions could cause flowers to bloom much later, or much earlier, then normal.

Over time, student's interest began to wane in their collection of data. They felt bogged down by the incidentals of data collection. Students struggled to maintain their data collection schedules and data collection became infrequent and/or observations were forgotten.

After working with this citizen science project for a year, I came to several conclusions. First, my students lacked the stamina for collecting data over such a long period. Even though we had a schedule for collecting data, students found the work monotonous and unappealing after several months. Second, my students understood the purpose of their work, but due to their lack of stamina, they became less invested over time. Towards the end of the school year, only two students were willing to help out with the observations. Third, after sharing my results with Chris Hass, a teacher at the Center for Inquiry, I realized choice was missing from these projects.

Constructing knowledge through purpose and investment in the classroom. Despite some setbacks, I knew citizen science was a worthwhile endeavor. Citizen science offered students a unique opportunity to contribute to scientific knowledge, while at the same time, learning about long-term data collection. By giving students *choice* in the citizen science projects they participated in, I believed they would take more ownership of their projects and feel more invested.

When the 2013-2014 school year started, I had students inquire into possible citizen science projects. As students searched for a project, there were three stipulations:

1) Projects had to be worked on during our explorations time;
2) Projects had to be free of cost;
3) Projects had to be worked on in groups.

Students spent explorations time searching the internet for citizen science projects they wanted to participate in. When students found a project that fit the requirements, they wrote down the name of the project and the website. After a week a list of projects were recorded for students to investigate (see Appendix L). Next, each student had to determine from the list which project they wanted to participate in. Students were placed into groups based on the project of their choice. These groups proved vital since they "allowed the kids to mentor one another and engage in collaborative inquiry by discussing their noticings, altering data collection to fit their individual needs, and [change] their data collection schedule based on challenges faced in the real world"

(Mills et al., 2014, p. 46). Groups made a schedule of when data would be collected and who would collect the data on a particular day (Appendix M).

I was able to purchase four iPad minis. Students inquired into whether their citizen science projects had an app, which were downloaded onto each iPad mini (see Figure 5.21). It was important to make data collection as user friendly as possible to continue keeping students invested. The iPad minis made data collection easier since students could upload data directly through the app. Since more citizen science projects relied on apps for data collection and analysis, the use of iPads became an authentic tool for inquiry.

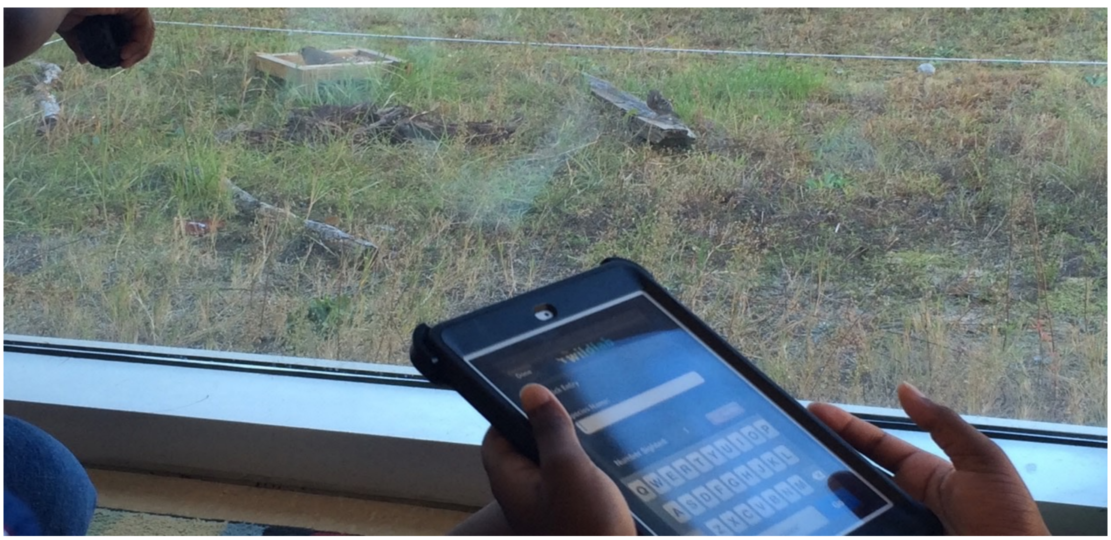

Figure 5.21. The use of iPad minis made citizen science projects user friendly.

As students participated in their citizen science projects, it was important to breath new life into their projects when possible. Sporadically through the year students demonstrated to other groups how to collect data. This allowed groups to briefly switch projects to get a sense of the kind of data other students were collecting. Some citizen science projects used weekly or quarterly emails to stay in contact with their participants. I shared these emails with students to help them connect to the larger citizen science community. A few citizen science projects used webinars as outreach to data collectors. Over time, we used a classroom Twitter account to stay connected with the citizen science community. Twitter allowed us to learn about new citizen science projects as they developed, and connect to the larger citizen science community.

The more groups participated in their respected citizen science projects, the more invested they felt. The more stamina they had to continue their projects, the more understanding students had regarding their particular project. For instance, Project Noah was a citizen science project intended to explore and document a variety of organisms. Students in this group were invested in their project. They spent time identifying the organisms found outside the classroom. As they gained more experience, the quicker and easier they would document organisms. This was also true of the Wild Lab Bird group, a group that explored and documented birds. Due to their experience of working with the project they could quickly identify a wide range of birds local to the area.

Synthesizing Knowledge Construction in Oregon and the Classroom

Dr. Helmuth and his colleagues created a community of practice in which knowledge was constructed within an authentic context. Noticing and naming particular conditions helped me create approximate conditions in my classroom. Once these conditions were in place, I noticed parallels and connections between the two learning contexts. Identifying these connections helped me make intentional decisions that created the conditions for the construction of knowledge. As a result of the data, I came to understand that my classroom was a specific type of community of practice – a classroom community of inquiry in which students took active and reflective roles in the development of their own understanding. The following table (Table 5.1) summarizes how knowledge was constructed in Oregon, how this influenced classroom decisions, and how knowledge was constructed in the classroom.

Table 5.1

Ways knowledge was constructed in Oregon and the classroom

	In Oregon…	**Influence classroom decisions…**	**In the classroom…**
Abductive Reasoning	Dr. Helmuth generated new hypotheses and altered current ones based on the evidence	Collaboratively designed curriculum that fostered and supported inquiry that nurtured healthy skepticism and experimentation	Using *I Think I Know…* folders, science journals, and diagrams to collect, explore, and question information. Statement of beliefs paper asked students to draw upon evidence and come to own conclusion
Talk • **Exploratory Talk** • **Information-seeking questions** • **Speak from the Heart**	Talk was primary way of communicating and constructing knowledge • Exploratory talk used to debrief about the day's experience; used to explore how to make the classroom an authentic learning environment like the Oregon experience • Information-seeking questions not observed in Oregon • Speaking from the heart not observed in Oregon	Exploratory talk was made explicit; flexibility of talk allowed students to use talk to construct knowledge Information-seeking questions framed the information students needed to develop their own conclusion Speaking from the heart used talk to provide a window into children's understanding of climate change through their diagrams	Exploratory talk used to make sense of diagrams and construct knowledge of global warming Information-seeking questions such as "What is global warming?" guided student's inquiry Students spoke from the heart when demonstrating their understanding of diagrams
Transmediation	Sensors were used to read stress levels of mussels; signs and symbols on the screen needed to be translated to another sign system to help others make sense	Students created diagrams, models, charts, and other visual representations to help them make sense of the content being studied	Students had to make sense of a variety of diagrams they studied; students came to understand what those signs and symbols meant, then translated those signs and symbols for use in their own diagram. New understanding of transmediation nudged me to envision other forms of expressing meaning such as through Legos and technology.
Building Upon Prior Knowledge and Experience	Dr. Helmuth built upon Tammy's prior understanding as a way of re-introducing her to using the laser level	I built upon student's prior understanding when I understood their funds of knowledge I often created metaphors that connected new knowledge to their funds of knowledge	As Allana, Alexi, Mary, and I discussed a diagram, I used metaphor to connect prior understanding with new knowledge Hannah used her prior knowledge to create a diagram of her understanding of climate change. She created

	In Oregon…	Influence classroom decisions…	In the classroom…
			metaphors such as cut trees to represent deforestation.
Observing and Pitching In	Tim and I observed and pitched in as Dr. Helmuth demonstrated how to use the gigapan	Observing and pitching in was a general term for how I organized lessons that encouraged students' active participation. Through their participation students felt a sense of belonging and ownership in the community and its activities	Brandon observed and pitched in as I demonstrated how to use the gigapan
Reflection	Dr. Helmuth reflected on the situation and developed an alternate plan to continue working and collecting data	Reflection took place before, and in the midst of classroom engagements, instead of solely after the fact	Alex reflected through *I Think I Know…* folders so he could see how his understanding changed over time. Jeena and Alexi reflected on their diagrams to help them talk through their understanding of climate change
Purpose and Investment	We used the same tools Dr. Helmuth and his colleagues used to collect data; we also used the same clothes which contributed to the authenticity of our work	To create a similar experience to Oregon the class participated in a citizen science project	Understanding choice was important, students chose a citizen science project to participate in; this lead to greater purpose and investment

CHAPTER 6

Implications and Conclusions

The following conclusion provides a brief overview of the purpose of this study, a summary of the procedures, findings, and implications.

Purpose of the Study

The purpose of this study was to identify features of learning, while apprenticing alongside Dr. Helmuth, as we collected climate change data. Those features were incorporated into my classroom to approximate conditions to Oregon. Incorporating those features allowed me to make connections, see parallels between the two learning contexts, and view my classroom as an approximate learning community. I intentionally made decisions, based on what I learned during the Oregon experience, to apprentice my students into constructing knowledge. The following questions guided this study:

- What features of the apprenticeship experience in Oregon nurtured inquiry and new understandings? How can these features influence classroom decisions?
- How was knowledge constructed in Oregon?
- How does my new understanding of knowledge construction influence future classroom decisions?
- How was knowledge constructed in my classroom after deliberately transferring and transforming insights from the Oregon experience?

Summary of Procedures

To investigate my research questions, I used qualitative research methods (Marshall & Rossman, 2006) within a teacher research model (Cochran-Smith & Lytle, 1993; Herr & Anderson, 2005; Hubbard & Power, 2012; Patterson & Shannon, 1993). During *Phase One*, the main methodological procedures included field notes, photographs, audio recordings, and video recordings. During *Phase Two*, the primary methodological procedures included observations and field notes, photographs, video recordings, and student artifacts. Data from both phases were coded and analyzed using the constant comparative method (Glaser, 1965; Lincoln & Guba, 1985).

Replicating the Oregon experience in my classroom would be impossible. Instead, I identified parallels and connections between the learning contexts in *Phase One* and *Phase Two* to approximate similar conditions. I identified parallels and made connections between the two learning contexts by coding and analyzing data across both phases, using the constant comparative method (Glaser, 1965; Lincoln & Guba, 1985).

Summary of the Findings

In order to answer my research questions, I identified features of the Oregon experience, which I shared in chapter four. My goal was to provide some background understanding of the Oregon experience and present how learning took place while apprenticing alongside Dr. Helmuth, which was reflected by the data. Based on the data collected, I identified the following features that nurtured inquiry and new understandings:

- Community activities
- Position as a learner

- Learning through demonstrations
- Demonstrating the skillfulness of inquiry
- Knowing-in-action
- Observing and pitching in
- Purpose and investment
- Independence

My understanding of these features helped me consciously make instructional decisions in the classroom, which approximated those structures found during the Oregon experience. As I analyzed those features of the Oregon experience, I came to understand that apprenticing under Dr. Helmuth was embedded within the community of practice that he nurtured.

In chapter five, after continued analysis of the data, I came to understand my classroom as a unique kind of a community of practice – a classroom community of inquiry. Identifying parallels and connections between the Oregon community of practice and my classroom community of inquirers helped me intentionally make decisions that fostered the construction of knowledge during a unit of study on climate change. I analyzed how knowledge was constructed in Oregon and the classroom. Knowledge in both contexts was constructed the following ways:

- Constructing knowledge through abductive reasoning
- Constructing knowledge through talk
- Constructing knowledge through transmediation
- Constructing knowledge by building upon prior knowledge and experience
- Constructing knowledge through observing and pitching in

- Constructing knowledge through reflection
- Constructing knowledge through purpose and investment

When I first apprenticed under Dr. Helmuth, I had no idea the experience would change me personally and professionally. It was refreshing and energizing to engage in the Oregon experience from the position of a learner. When I had the opportunity to apprentice with him a second time, I wanted to uncover what made learning so meaningful and memorable, and approximate similar conditions in my classroom.

Approximating similar conditions did not entail attempting to re-create the same tasks we engaged in Oregon. This would be impossible since the tasks and tools we used were specific to that environment and the kinds of data collected. This meant looking below the surface to identifying beliefs that underpinned the conditions for learning that were driving the Oregon experience. Understanding these conditions influenced my view of learning, which in turn, influenced decisions made in the classroom. These decisions helped facilitate the creation of a classroom community of inquiry whose focus was on collaborating in the construction of knowledge.

Implications for Teachers: Growing New Beliefs and Practices

Wells (2001a) summed what I came to understand as a result of this research:

> Teaching, like learning, involves an active co-construction of knowledge in collaboration with particular students in a particular place and time. It also involves the teacher as an individual, who has values, beliefs, and interests, as well as preferred ways of working with students, that have been learned and modified over the course of a lifetime of personal and professional experience. (p. 176)

Critical incidents in my teaching came as a result of engaging in systematic, self-critical inquiry into my own beliefs and teaching practices (Cochran-Smith & Lytle, 1993; Stenhouse, 1981, p. 103). Harste, Woodward, and Burke (1984) wrote, "As professionals we have the responsibility constantly to put the assumptions underlying our beliefs to the test" (p. 50). This research provided a medium which nudged me to reflect upon those critical incidents in order to expose my beliefs about teaching and learning. The following implications for growing new beliefs and practices are geared towards teachers, and reflect my growing beliefs and practices which resulted from this research:

- Teachers must undergo belief maintenance
- Teachers must position themselves as learners

Teachers must undergo belief maintenance. Schreiber and Moss (2002) refer to teachers examining their beliefs in a reflexive manner as *belief maintenance*. If teachers are expected to be scholars and lifelong learners who demonstrate the processes of inquiry alongside their students (Schreiber and Moss, 2002), they must be comfortable with self-critical inquiry into their own practices. Unfortunately, belief maintenance can be difficult and uncomfortable because it takes up much energy. For instance, inquiring into my beliefs about learning was a struggle at times because it made me self-conscious and uncomfortable. It was synonymous with placing a mirror in front of me so that my flaws were uncovered. At the same time, growth in knowledge does not take place in the midst of complacency. Engaging in belief maintenance helps grow new beliefs and practices.

For instance, I knew the exploratory talk I engaged in with Allana, Alexi, and Mary (see Appendix F) was a critical incident because the four of us participated in a dialogue in which we left the conversation having much more knowledge and understanding then when we entered the conversation. I did not understand why the conversation was so critical until I asked, "Why?" This question nudged me to inquire into what made this conversation so critical. Once I transcribed the conversation and came to understand the knowledge we were constructing, according to my field notes, "I wanted them [students] to have that same understanding of global warming so I wanted them [students] to do something similar – I wanted them to find some diagrams that would help them make better sense of global warming through talk" (Field Notes – 2/12/13). As I reflected on this critical incident, I came to believe that talk was not just a by-product of living and learning in an inquiry-based classroom, but was a part of the skillfulness of inquiry, and the primary means of constructing knowledge in my classroom community of inquiry.

On the flip side, self-critical inquiry forced me to come to understand why I approached working with one child different than another. As students were reading and responding to global warming diagrams, I stopped to talk with Chris and asked if he would share his understanding of the diagram he chose. He immediately demonstrated his difficulty with understanding the diagram. As I listened to him, I told him to "Read it better, read a little bit better" (Field Notes – 2/12/13). I was not aware of this comment until I transcribed the event, but I immediately knew *reading it better* would not improve his understanding of the diagram. So why did I *not* sit down with Chris and engage in some type of exploratory talk, even it meant scaffolding the diagram more with him than with other students? Belief maintenance led me to consider that while I believe I should be responsive to all students' curricular needs, I unconsciously did not feel that Chris deserved my help during this particular incident because he chose a diagram that was too difficult. I reacted instead of responding; instead of helping, I blamed. More important, through a process of belief maintenance, I came to understand that I am fallible, I take responsibility for my actions, I am capable of making such instructional mistakes, and I need to be mindful of how I responded to not only Chris in the future, but all my students. Realizing past mistakes helps teachers make better decisions in the future.

Teachers must position themselves as learners. As a teacher researcher, I learned that teachers will grow new beliefs and practices when they position themselves as learners. Professional inquiry alongside my peers and students served as a catalyst for belief maintenance. For example, Mills et al. (2014) believes that professional development should go beyond simply interacting and engaging with peers, but should extend to professional inquiry *alongside* peers. Instead of lectures that attempt to connect random information with unfamiliar classroom contexts, professional inquiry should focus on growing new beliefs and practices. When teachers position themselves as learners, they grow professionally by noticing and naming beliefs that underpin their practice when exploring classroom videos and student artifacts (Mills et al., 2014). The power of inquiring alongside my students provided new perspectives of the world and the curriculum. Thus, collaborating alongside my students helped me grow new beliefs and practices by providing new insights into what I thought I already knew and understood.

At the conclusion of Chapter Two, I wrote that I felt my teaching practices did not always live up to my beliefs. Placing myself in the position of learner during the Oregon experience provided a new lens from which to view learning. Being able to experience learning through this lens, reflecting on the learning that took place, then growing new practices from these new beliefs, had a tremendous impact on my personal and professional growth. While the Oregon experience provided a foundation from which I began examining my classroom beliefs, the unit of study on climate change nudged me to reflect on what I believed about teaching and learning, while simultaneously providing an arena to grow new practices from beliefs.

Theorizing From Practice: Implications for Teachers and Practice

The beliefs that underpinned my initial theoretical framework (see Chapter One) grew and changed as did my practices. As a result, I have come to understand that beliefs and practices are heavily intertwined, and each one is a reflection of the other. I also learned how to theorize from practice as I collected and analyzed data across contexts. In so doing, I learned the value of taking action from a reflexive stance. In the end, that's the purpose of delineating implications. As teachers at CFI have grown accustomed to helping kids learn to ask: So what? And Now what? when completing an inquiry, I recognize the importance of teasing out implications from teacher research. Therefore, the following implications have grown from my evolving theoretical framework which guided this study:

- Inquiry as collaborative process of knowledge construction
- Community
    - *Community is important in helping students construct knowledge*
    - *The classroom as a community of inquirers*
- Children and adults exploring together
    - *Apprenticing alongside real scientists*
    - *Apprenticing alongside students*

- Curriculum as inquiry
    - *Questions are critical*
- The child as curricular informant
    - *My students informed me of the importance of purpose, investment, and choice in facilitating knowledge construction*

Inquiry as a collaborative process of knowledge construction. This research demonstrated that inquiry is a collaborative process of knowledge construction (see Figure 6.1) and is supported when the curriculum is grounded in inquiry, the child is viewed as a curricular informant, classrooms become communities, and when children and adults explore together. The true power of teacher research and professional inquiry takes place when teachers research in front of and alongside their students (Mills et al., 2004). This was evident in the unit of study on climate change. While I had previously

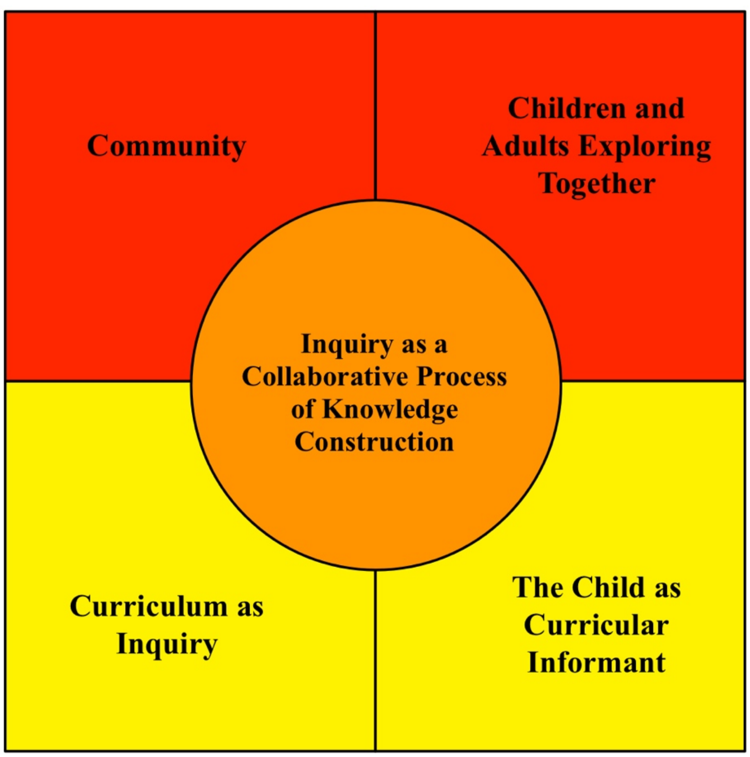

Figure 6.1. Inquiry as a collaborative process of knowledge construction.

never engaged students in a study of climate change, I had specific beliefs about the knowledge I wanted students to construct. This knowledge was constructed when students engaged in the skillfulness of inquiry, which was embedded in the unit of study. In the midst of the unit of study, the classroom community of inquiry created a shared repertoire of ways we constructed knowledge, through practice, in the midst of the unit of study. This shared repertoire was negotiated as we collaborated together. Students and I grew in our understanding of climate change as we inquired alongside each other. It was when students and I researched together I realized that students grew new beliefs about climate change in the same manner I did such as through the same processes of abductive reasoning and reflection (e.g., see Appendices G, H, I). In other words, “The process that propels our professional growth parallels the process that promotes growth and change in our students’ belief’s and practices” (Mills et al., 2014, p. 39). Just like the zone of proximal development creates a learning environment that nudges all participants in the learning process, collaborative inquiry within a classroom community of inquiry created a space for students and myself to grow new beliefs and practices.

Community. Ralph Peterson’s (1992) view of community has been my *de-facto* view of learners coming together to create a nurturing and supportive environment. The work of Lave and Wenger (1991) and later Wenger (1998) concerning communities of practice expanded my view of the importance of community, to include communities of learners who nurture and support each other in the construction of knowledge. Students and teachers are active participants in this community as they seek information that helps them go beyond their present understanding. Wells (1999, 2001b) continued to push my thinking beyond communities of practice and notice and name my classroom as a *classroom community of inquiry* – an important insight in helping me notice and name the shared repertoire of ways we constructed knowledge in this community.

The classroom as a community of inquirers. Envisioning my classroom as a classroom community of inquiry was important because it validated the learning context I attempted to create. The classroom context is a learning environment that has unique potentials and challenges that must be considered and validated. Wells (2001a) believes that,

> Each classroom must find its own way of working, taking into account both what each member brings by way of past experience at home, at school, and in the wider community – their values, interests, and aspirations – as well as the outcomes that they are required to achieve. (p. 174)

As a teacher researcher, I brought the individual personalities and idiosyncrasies of my community members together in the pursuit of inquiry. Nowhere else are these personalities and idiosyncrasies more embraced than within a community setting. The classroom community of inquiry built on the strengths of individuals and their funds of knowledge (Moll et al., 1992) as they searched for the answers to their questions. When our community inquired into climate change, each member contributed in some manner, which helped us create a shared repertoire of ways we constructed knowledge. My classroom at the time of this study was made up of academically diverse students. Yet, through our unit of study on climate change, labels such as *struggling* or *proficient learner* were virtually nonexistent because all voices were valued and universal participation was expected. Engagements within the unit of study were open-ended, and each child's background knowledge of climate change was honored no matter the amount of knowledge they possessed. Instead of standardizing my students and their processes for learning, inquiry was the great equalizer; it was our search for knowledge and understanding that placed everyone on equal footing, and each individual's contributions, no matter how big or small, was valued.

Community is important in helping students construct knowledge. This research demonstrated the importance community plays in the construction of knowledge. The critical incidents shared in this research have one thing in common – knowledge was constructed in the company of others. During the Oregon experience, knowledge was constructed as teachers from the Center for Inquiry apprenticed alongside Dr. Helmuth and his colleagues. Through the course of the unit of study, knowledge was constructed as students and teacher apprenticed one another through such processes as exploratory talk, and the reification of our thoughts and understandings through artifacts such as diagrams. Much of the community constructed knowledge occurred through abductive reasoning – a process Shank (1998) refers to as being *extraordinarily ordinary* because of a human's ability to learn through abductive reasoning in ordinary, day-to-day settings. Shank (1998) believes that the power of abductive reasoning lies not in the creation of new truth, "but to generate new insights that lead to more sophisticated levels of meaningful understanding" (pp. 845-846). The unit of study on climate change demonstrated learning through a process that built from children's prior knowledge, to children reaching their own conclusion based on the evidence (see Appendices G, H, I). As the classroom community of inquirers wrestled with climate change information, their general insights became more sophisticated over time through practices such as talk (e.g., exploratory talk), reflection through *I Think I Know…* folders, and the creation of diagrams. The community created a space in which multiple voices were valued and allowed to flourish, such as when students like Jaci were skeptical of particular climate change evidence.

Children and adults exploring together. My true joy in teaching comes from exploring alongside my students – they often see the world through a perspective I may no longer be privy to. Carson (1956) says that,

> A child's world is fresh and new and beautiful, full of wonder and excitement. It is our misfortune that for most of us that clear-eyed vision, that true instinct for what is beautiful and awe-inspiring, is dimmed and even lost before we reach adulthood. (p. 46)

While I may not always be able to wonder and explore alongside my students in the sense of allowing my students to freely connect with the outdoors (Dunlap and Kellert, 2012), I see the apprenticeship model as a metaphor to describe the relationship between novices and experts as they collaboratively construct knowledge in any learning context.

Apprenticing alongside real scientists. The research demonstrated when elementary school teachers have the opportunity to apprentice alongside real scientists, and engage in meaningful scientific research, it has the potential to transform classrooms and its practices. Apprenticing alongside those with more experience places elementary teachers in a position as learner and allows them to consider teaching and learning from the perspective of the learner. Bower (2005) feels scientists have an obligation to model the scientific process so that teachers can experience the excitement of authentic, scientific research. I understood my classroom would not be able to mimic the scientific practices we learned in Oregon, such as counting and measuring the arms of pisasters.

But more important, through the Oregon apprenticeship experience, I transformed my classroom by growing new beliefs which led to new practices.

Apprenticing alongside students. While the Oregon experience pushed me to rethink the importance of creating authentic learning experiences for my students, it also pushed me to rethink my role in the classroom, and my relationship with my students. The metaphor of the apprentice model seemed fitting because it provided a model for exploring alongside my students. For instance, notions of children and adults exploring together pushed me to re-examine my classroom explorations time as an opportunity for students to inquire into those things they are interested in or passionate about, often collaborating alongside others. Explorations provides an additional curricular structure to "inquire in front of and alongside [my]students" (Mills et al., 2014, p.38). For this reason, I have embraced the *maker movement* in which "kids and teachers learn together through direct experience with an assortment of high and low-tech materials" (Stager, 2014). Just like teachers who bring into the classroom their passion for music, social justice, or mathematics, my passion for tinkering and taking things apart feels like a natural extension of who I am. Sharing this passion with my students builds stronger relationships. Items brought into the classroom are explored, not because we know how to use them, but because we *want* to learn how to use them to further inquire, much like the tools we used in Oregon.

Students and I explored circuitry and basic computer programming as we worked with Arduinos – an open source electronic prototyping platform that allowed us to create interactive electronic devices (see Figure 6.2). LittleBits allowed us to create a variety of different electronic devices without soldering. We built cars, arcade games, and dance pads out of cardboard, then integrated a variety of electronics to create things such as

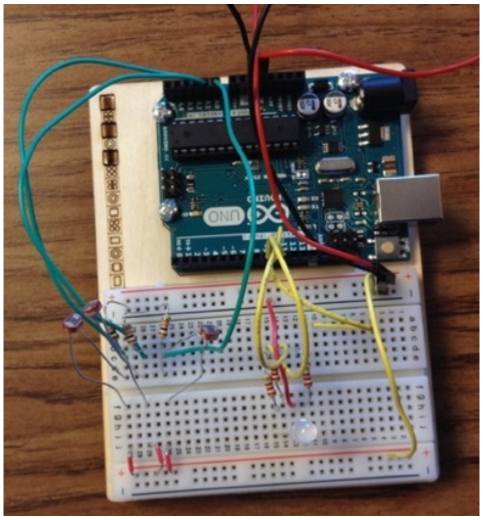

Figure 6.2. Arduinos allowed students to inquire about open-source electronics and computer programming.

robots and laptop screen projectors (see Figure 6.3). Students also explored circuitry using Squishy Circuits and Snap Circuits, took apart broken appliances and computers to see how they worked, and made their own board games.

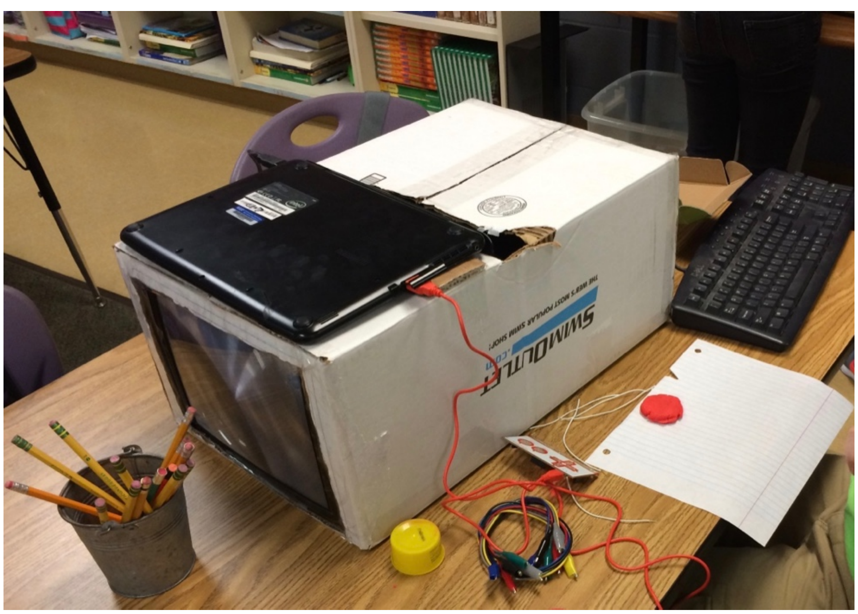

Figure 6.3. Student created laptop screen projector.

Curriculum as inquiry. Mills (2014) states that, “Curriculum is the transaction that occurs among teacher, students, and resources within and across curricular structures” (p. 102). When my curriculum focused on inquiry, knowledge construction took place in the transaction. The unit of study I envisioned emphasized students taking active and reflective roles in the construction of knowledge of climate change, and created opportunities for students “to name and experience the processes of inquiry” (Mills et al., 2014, p. 101). As students constructed knowledge, they learned the skillfulness of inquiry because it was embedded within the unit of study, such as coming to understand climate change through abductive reasoning, allowing students to use talk to explore and discover new ideas, and encouraging students to be skeptical and notice information from alternative perspectives. In the words of Mills (2014), “The universal processes of inquiry are grounded in the specifics of [the] unit” (p. 9).

Questions are critical. This research demonstrated that questions are a critical component of curriculum as inquiry. This study brought to light how much I underestimated the power of a question. Just like well-thought curriculum supports inquiry, a well-thought question supports the skillfulness of inquiry. The type of question asked nudges students towards certain processes of inquiry. For instance, information-seeking questions framed the information students needed to uncover, as this type of questioning pushed my students to further inquire as they “follow[ed] the logic of an authentic question” (Mills, 2014, p. xix). The question was open-ended enough to allow students to construct knowledge in a manner that was personal to them, such as Maria using diagrams to make sense of global warming. At the same time, the amount of information needed to be uncovered was framed so as not to be too overwhelming and time consuming. When curriculum focused on inquiry, the unit of study on climate change focused on teaching the necessary skills and strategies to inquire as the unit addressed the content.

This research pushed me to rethink questions and how I framed them. For example, when I created questions to assess student understanding in social studies, I have slowly moved away from assessments dominated by multiple choice questions, to questions that engage students in personal reflection by considering various perspectives. For example, Johnston (2004) pushed me to frame questions in a manner in which students must consider the perspective of a particular individual, then answer the question through the lens of that person. As an example, during Social Studies, I assessed students understanding of the Progressive Era by asking questions such as

- As an immigrant from Italy who is traveling to America, how might he or she describe New York?
- How might "new world" immigrants describe the trip to America?
- How might "new world" immigrants describe the process of immigrating through Ellis Island?
- What do you think Jacob Riis was thinking as he photographed New York tenement buildings?
- How would workers at the Triangle Shirtwaist Factory view their job?

Instead of asking students to recall bits of information through multiple-choice questions, questions that asked students to consider the perspectives of the cultures and people we study asked students to draw from their understanding across multiple sources, such as classroom discussions, videos, textbooks, trade books, and primary documents, in order to reach a general conclusion. Student's questions were followed up by using their responses to begin a conversation about their thinking.

The child as curricular informant. The findings from this study reveal the importance of allowing students to act as curricular informants. Maria acting as a curricular informant during this study should not be underestimated. Allowing students to conduct research by providing them questions that framed the information that needed to be found gave Maria enough freedom to use her own processes for inquiring. As I worked alongside her, I repositioned myself in a manner that allowed me to learn from her. What I uncovered from the data that is of most importance was that I *acted* on what I learned from Maria. When Maria demonstrated the importance of diagrams in helping her construct knowledge, I acted on this knowledge and allowed it to inform future practice - not only during this unit of study of climate change, but all future units of study. Children can only inform the curriculum when we allow them to.

My students inform me of the importance of purpose, investment, and choice in facilitating knowledge construction. The findings from this research demonstrated that purpose, investment, and choice were an important component of the Oregon experience and my classroom citizen science projects. My new understanding led me to create experiences, such as citizen science projects, that offered students choice, so they could understand the purpose of their work, and be invested in the activity. Over time, students constructed knowledge of the activity through prolonged engagement.

Once my awareness was heightened, I continued to take cues from the children around me and I began to see how purpose, investment, and choice facilitated knowledge construction in the everyday lives of children. For instance, during the Rainbow Loom craze, I was amazed at how quickly students picked up a loom and learned to make creative and fantastical items such as bracelets, purses, and dolls. During explorations, my students would sit intently at their computers and watch instructional videos, recreate those items, then share their knowledge with others. They also brought in duct tape and created wearables such as purses and bags. Students chose the activity they wanted to learn about because they saw purpose in the activity. Their investment in the activity provided the stamina to move forward, deepening their knowledge about the particular in this manner. I believed if my students were in touch with their own processes for learning, this understanding would transfer to other areas of the curriculum such as reading, writing, math, and science.

Because students have informed me of the importance of purpose, investment, and choice in their everyday learning, I restructured my explorations time to ensure students had opportunities and time to chose things they wanted to explore. Students engaged in the skillfulness of inquiry as they inquired into things of their choosing such as when two students worked together to problem solve how to re-program a Makey Makey, an invention kit that turns everyday items into touchpads. When students found purpose in their work, their investment drove the inquiry. Many students conducted their own mini-inquiries as they researched topics that interested them. These topics ranged from researching a particular animal or country, to creating a complete news report that included the world news, sports updates, and the weather. To provide further purpose, students were encouraged to share their inquiries during our sharing time. As students shared, it inspired others to engage in similar inquiries. Thus, sharing inspired a never-ending cycle of inquiry nudged by choice, purpose, and investment.

To continue supporting the construction of knowledge through purpose, investment, and choice, I continue engaging students in citizen science projects as a weekly curricular structure. Students researched various citizen science projects that could be conducted during the school day. All projects are worked on in small groups, and students collaborate alongside each other. The tasks that students work on have expanded to include a variety of unique projects. For instance, one group of students flips state quarters to collect data on the fairness of particular coins landing on either heads or tails. Each week they chose a new state quarter to flip and upload the data to a website (http://physicsbuzz.physicscentral.com/2013/08/citizen-science-testing-fairness-of-us.html). To make sure they systematically collect valid data, they created their own guidelines to make sure their data was accurate. Another group takes pictures of the organisms that live outside our classroom and uploads them to another website (www.projectnoah.org). Through investment and prolonged engagement, they have developed their own system for recording and uploading data. Because of this, more than a dozen organisms have been identified through their data collection.

Implications for Further Research

Based on the findings from this study, I suggest the following implications to further grow new beliefs and practices for elementary school teachers and inquiry-based pedagogy:

- Teachers apprenticing under scientists engaging in meaningful scientific research
- Citizen science
- The skillfulness of inquiry

Teachers apprenticing under scientists engaging in meaningful scientific research. In a study by Miranda and Damico (2013), they state that research experiences for teachers are on the rise because of the notion that engaging in authentic scientific endeavors improves science teaching, which in turn, improves the quality, authenticity, and scientific achievement. The problem with this notion is that it focuses on reforming scientific teaching at the practice level. This research demonstrated that teachers who apprentice under scientists engaging in meaningful scientific research should concentrate on reforming their teaching practices by focusing on growing new beliefs - from new beliefs grow new practices. Experiences in which teachers and scientists work together may starkly contrast the classroom, especially the laboratory settings of the high school science classroom. For instance, when one teacher responded to their apprenticeship experience, they acknowledge that their classroom was not student-centered and that experimentation was teacher directed (Miranda and Damico, 2013). Practices gained from apprenticeship experiences will not work if a community of inquiry, similar to scientists, is not established.

Citizen science. In this study, citizen science was brought into the classroom to provide students an experience that approximated conditions to the Oregon experience. These conditions included engaging students in authentic, scientific data collection that contributed to the scientific community. I believe this study did exactly that. But the findings from this study also highlight the need for continued research advocating citizen science projects in the elementary classroom.

Mills et al. (2014) demonstrated that citizen science projects in inquiry-based classrooms provided opportunities for students to research alongside teachers without the need for vast amounts of labor and resources. Citizen science projects provide an opportunity for students to take their findings public and connect them to a larger community beyond the walls of the classroom. This provides a deeper sense of purpose and investment. Citizen science has the potential to become a curricular structure, alongside science, in inquiry-based classrooms because these projects offer an experience that approximates the conditions for authentic scientific inquiry. Further research by classroom teachers offers opportunities to create a dialogue as to how best to implement these projects in inquiry-based classrooms.

The skillfulness of inquiry. I felt my beliefs and practices were not always aligned, because I questioned that I created opportunities for my students to engage in the skillfulness of inquiry. I worried that my focus on working with state standards was diluting inquiry to the point we were inquiring in name only. This research uncovered the opposite. The findings from this research demonstrated that the skillfulness of inquiry is personal (e.g., each person has a unique set of processes they use for inquiring such as Maria and her diagrams), is multifaceted and includes the manipulation of the physical world (e.g., tools used for inquiring such as gigapans), involves mental processes (e.g., abductive reasoning), involves processes of communication (e.g., talk and transmediation), and *will* exist in some manner in classrooms communities of inquiry. The difficulty lies in the identification of particular processes involved in the skillfulness of inquiry. That is, I had difficulty noticing the skillfulness of inquiry because of my lack of understanding. It would be exciting to research a variety skills and processes individuals use to inquire, in and out of the classroom, to continue expanding our understanding of inquiry as a philosophical stance, and to support a wide variety of classroom experiences which support the skillfulness of inquiry.

Conclusion

Frank Smith (2006) states that what makes up *ourselves* is language, and it is through language "that much of what we think and perceive appears to be self-evident to us" (p. vii). New beliefs grow from the language we use when we notice and name the practices that underpin our current thinking (Mills, 2014). This research provided a medium to use language to articulate beliefs and practices, while simultaneously growing new beliefs and practices. Halliday (1993) stated that "language is the essential condition of knowing, the process by which experience becomes knowledge" (p. 94). Systematic, self-critical inquiry into my own beliefs and practices through this research provided the language to turn experience gained through the Oregon experience, and the unit of study on climate change, into better understanding how my teaching practices were aligned with my beliefs about teaching, learners, and learning.

Learning is not about memorization, but about growth. Through this research I have grown both personally and professionally. Much of my growth came as a result of my reflections on observing others. Frank Smith (2006) states,

> Everything we know about ourselves we have got from other people, either from what they have told us (or written) or simply by observation of them. The basis of language (and of learning) is social…we don't learn what we're like from looking inside ourselves, but from looking at other people. (p. 8)

The Oregon experience and my classroom provided two learning communities from which to slow down, observe people, and notice and name. As a result, I am no longer the same teacher. I have developed many new beliefs about learning through this research - probably more beliefs than practices. Fortunately, when we inquire, we usually envision new beliefs before our practices (Mills et al., 2014). This will suit me well in the future as I adapt and respond to changing standards, and more important, new students.

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APPENDIX A

Teacher Consent Form

Inquiry as a Way of Life:
Fostering Genuine Inquiry Through Reflexive Action
Consent Form

My name is Scott G. Johnson. I am a doctoral candidate in the Language and Literacy Department at the University of South Carolina. I am conducting a research study as a part of the requirements of my degree in Language and Literacy, and I would like you to participate.

The purpose of my study is to reflect on myself as an inquirer. As a result of this reflection, I hope to take what I have learned of myself as an inquirer and apply those characteristics in the classroom. I understand that inquiry is social and that what I come to understand of the world is influenced by those around me.

As a part of my study, I will be taking photographs, audio, and video recordings of what takes place in the field. Photographs, audio, and video recordings will be analyzed and coded. I will also take audio and/or video recordings of discussions we have concerning what we have learned from our climate change research in Oregon. These audio and/or video recordings will be analyzed and coded at a later date. I am asking that I be allowed to use any photographs you may be present in as a part of my study. I am also asking that I be allowed to use any audio or video recordings of discussions in which you are a part of, including comments if necessary, as a part of my study.

There should be no risks to you as a participant in this study. Although you may probably not benefit directly from participating in this study, I hope the results of this study will benefit the teaching community.

Participation will not be confidential, and as a means of honoring you and your help, I would like to use your name to recognize how much you have influenced my research. The results of the study may be published or presented at professional meetings.

Taking part in the study is your decision. You do not have to be in this study if you do not want to. You may also quit being in the study at any time.

I will be happy to answer any questions you have concerning my study. You may contact me at 803-528-8434, the Center for Inquiry at 803-699-2969, or my dissertation advisor, Dr. Heidi Mills at heidimills@sc.rr.com. If you have any questions about your rights as a research participant, you may contact the Office of Research Compliance at the University of South Carolina at 803-777-7095.

If you are willing to participate, please sign the bottom of this form. You will be provided a copy of the form if requested.

Adult Signature Date

APPENDIX B

Student Consent Form

Inquiry as a Way of Life:
Fostering Genuine Inquiry Through Reflexive Action
Consent Form

My name is Scott G. Johnson. I am a doctoral candidate in the Language and Literacy Department at the University of South Carolina. I am conducting a research study as a part of the requirements of my degree in Language and Literacy, and I would like you to participate.

The purpose of my study is to reflect on myself as an inquirer. As a result of this reflection, I hope to take what I have learned of myself as an inquirer and apply those characteristics in the classroom. I understand that inquiry is social and that what I come to understand of the world is influenced by those around me.

As a part of my study, I will be taking photographs, audio, and video recordings of what takes place in the classroom. Photographs, audio, and video recordings will be analyzed and coded. I will also take audio and/or video recordings of discussions we have concerning what we have learned from our climate change research in Oregon. These audio and/or video recordings will be analyzed and coded at a later date. I am asking that I be allowed to use any photographs your child may be present in as a part of my study. I am also asking that I be allowed to use any audio or video recordings of discussions in which your child is a part of, including comments if necessary, as a part of my study.

There should be no risks to your child as a participant in this study. Although they probably will not benefit directly from participating in this study, I hope the results of this study will benefit the teaching community.

Participation is confidential. The results of the study may be published or presented at professional meetings but your child's identity will not be revealed.

Taking part in the study is you and your child's decision. Your child does not have to be in this study if they do not want to. They may also quit being in the study at any time.

I will be happy to answer any questions you have concerning my study. You may contact me at 803-528-8434, the Center for Inquiry at 803-699-2969, or my dissertation advisor, Dr. Heidi Mills at heidimills@sc.rr.com. If you have any questions about your child's rights as a research participant, you may contact the Office of Research Compliance at the University of South Carolina at 803-777-7095.

If you are willing to allow your child to participate, please have you and your child sign the bottom of this form. You will be provided a copy of the form if requested.

____

Parent Date

I have read the description of the study titled Inquiry as a Way of Life: Fostering Genuine Inquiry Through Reflexive Action and I understand the procedures and content of the study. I have received permission from my parent(s) in the project, and I agree to participate in it. I know that I can quit the study at any time.

____

Signature of Minor Date

APPENDIX C

Ways Knowledge was Constructed

Table C.1

Ways Knowledge was Constructed

	In Oregon…	Influence my classroom decisions…	In the classroom…
Talk • **Speak from the Heart** • **Exploratory Talk**	While debriefing after time in the field, teachers engage in exploratory talk discussing the needs for authentic tools scientists use, to be used in the classroom, and the importance of careful and systematic observation. Teacher's exploratory talk discussed the importance of students feeling passionate (purpose & investment) in the tasks they participate in.	I originally would allow students to write much information on note cards and their presentation. I now emphasize more speaking from the heart so I can get a better representation of their understanding of a particular topic.	After looking at pictures of receding glaciers which attempt to demonstrate global warming taking place, students engage in exploratory talk in their groups to discuss what evidence, to them, was the most compelling for climate change.
Reflection	Brian and his team improvised much in the field. As surprises took place out in the field, they needed to be willing to make changes on the spot in order to collect information that would yield better results.	Reflection has become a natural part of positioning ourselves as inquirers. To inquire means to be reflective – we reflect on what we already know and make changes to this understanding based on new information. Reflection helps students determine where this new information fits in with current beliefs.	We often reflected through the use of reflection journals in which we reflect on what we already know. We also used diagrams as a means of reflection. As students create their diagrams, they reflect on their current understanding as a means of
Reasoning (Abductive)	Scientists have to take the data they collected and generate hypothesis based on the findings across all their data. When new data is presented, this could change the current hypothesis But for Brian to abductively reason, Brian needed to be up to date on current research concerning climate change. Brian was always willing to accept data which may alter new understandings of climate change.	In order for students to abductively reason, I need to be aware of the authority I hold in the classroom. Through my awareness of authority, I can better facilitate students fixing their beliefs through inquiry than authority. I need to be more aware of how I attempt to objectively present information that may sway the beliefs of young children. I also need place more of an emphasis on presenting multiple perspectives of a topic so that students can generate their own hypothesis based on a multitude of information from various beliefs and perspectives.	The entire purpose of my climate change unit of study was to abductively reason. I wanted each child to analyze the data we transacted with, reflect on their understanding of this information, and come to some type of conclusion concerning their beliefs of climate change at that time.

Purpose	We came to understand our work had purpose. We could see that our work was going to be used by others (scientists).	This year each child picked a citizen science project they would conduct over the year. Based on the projects, students were placed into 7 citizen science groups. Based on the expectations of each particular project, students came up with their own schedule when project would be conducted. Long-term, systematic data collection and analysis with a purpose, leads to student investment in their work. They understand their data collection contributes to the knowledge base in that particular field. Students see their work as having a purpose and not conducting work for the sake of work.	Engaged students in a citizen science project (cloned dogwood tree). We developed a schedule for observing the trees but most students did not see the purpose and were not invested in project. Only few were invested in the project so they continued with this particular project.
Investment • **Initiative** • **Independence**	Teachers engaged in data collection of various types. Data collection included taking gigapan pictures, measuring sea stars, collecting tube feet, taking height measurements. We understood the purpose of our work so we were invested in out work. Our investment led to our understanding of our work. Once we truly understood the nature of our data collection, we independently took over the task.	This year each child picked a citizen science project they would conduct over the year. Based on the projects, students were placed into 7 citizen science groups. Based on the expectations of each particular project, students came up with their own schedule when project would be conducted. Long-term, systematic data collection and analysis with a purpose, leads to student investment in their work. They understand their data collection contributes to the knowledge base in that particular field.	Engaged students in a citizen science project (cloned dogwood tree). We developed a schedule for observing the trees but most students did not see the purpose and were not invested in project. Only few were invested in the project so they continued with this particular project.
Community Generated Knowledge	A variety of data was collected. Scientists will generate some kind of hypothesis or alter in some manner current hypothesis concerning global warming and climate change. The community of inquirers rely on each other's data to generate hypothesis which helps to explain what they observe	When communities of inquirers collaborate in the spirit of generating knowledge, this knowledge is accessible to all participants in the classroom during a shared meeting time. When inquirers participate in the inclusion of this shared knowledge, they confirm their own understanding, clarify any misunderstandings independently or collaboratively, and/or they can alter existing information as new information is generated. Students often use this shared knowledge as a beginning foundation from which to build new understanding. As the classroom teacher, I use this	Students collect information from a variety of sources such as books and the internet. The information that is generated from their research is shared with the whole class. When we share this information as a group, we add knowledge into our collective understanding of climate change. As students share their understanding, students help clarify miscues in understandings or validate current understanding

		shared knowledge to help students make connections between their prior knowledge and new learning.	
Build Upon Prior Knowledge / Experience • **Metaphor / Analogy** • **Personal Stories**	Tammy had used the laser level before but felt unsure after not using it for a year. While Brian demonstrated how to use it, he builds off of what Tammy already knew of using the laser level.	Before beginning any lesson, reading, etc., I make connections between what we are about to engage in to previous experiences in order to help students consciously make connections between new and old knowledge. I also do this by creating metaphor, analogies, and personal stories. As I engage students in exploratory talk, I'm attentively listening, trying to create metaphors or adding personal stories when possible.	Before beginning my study of climate change, I began our normal study of weather. Our study of weather provided a foundation for our study of climate change in which students can build from. Students use metaphor while explaining their diagrams. For instance, Hannah write CO2 bigger than the other gases to metaphorically represent that CO2 was the most common greenhouse gas in the atmosphere. Pictures metaphorically represent causes of greenhouse gases such pictures of cut down trees in Africa represent deforestation. I created metaphors comparing global warming to being trapped in a car with the windows rolled up.
Transmediation	When Brian uses the tools of his trade, he has to make sense of the signs those tools use to represent meaning. For instance, the laser level uses a variety of signs to represent height, the computer used to measure the stress levels of mussels uses signs to represent the stress levels that have to be translated into graphs to be understood	I have students use diagrams more often to represent their thinking in social studies (connections and relationships), mathematics (represent problems visually), science (use diagram software to represent connections and relationships), writing (use diagram software to represent thinking before writing)	Students create diagrams to represent their understanding of climate change (i.e., global warming). Next, through the diagram, students orally share their understanding of climate change

APPENDIX D

Unit of Study on Climate Change

Planning Units of Study: Center for Inquiry

Envisioning Possibilities: Planning on Paper

Our best planning comes from making predictions and creating conditions *for students to engage in particular kinds of thinking (for example, strategies, skills, and content connections).*

When planning demonstrations or engagements*, it is critical to ask ourselves what kind of thinking, conversations, and learning strategies we want to promote.*

Bringing Plans to Life

Curriculum is the transaction occurring between teacher, students and resources within and across curricular structures; such as morning meetings, reading, writing and math workshops and units of study in the social and physical sciences.

Responsive teaching *is about identifying patterns in kidwatching data and planning responsively for individuals, small groups and for whole class instruction. From kidwatching to curriculum, from moment to moment, as well as planning ahead—the teacher designs mini-lessons deciding what or who to highlight during strategy sharing sessions.*

Creating curriculum with and for children *to help them think, work and communicate as readers, writers, mathematicians, scientists and social scientists by working within an apprenticeship model (working in-front-of, along-side and behind students).*

(Mills with CFI faculty, 2008)

Unit of Study: Climate Change

Grade Level: 4th Grade ***Date: 1/5/12***

Beliefs that Underpin this Inquiry

1. Inquiry begins when we encounter situations in our world that seem strange or hidden and cause us to pause and wonder. Within these situations, we naturally engage ourselves in making sense of what we encounter.
2. We are spurred to inquire when we encounter situations that have a direct effect on who we are and how we live in the world. Curriculum should capitalize directly on situations that are as close as possible to students' direct experience and their effects on the world.
3. We learn best when we interact with information in lots of ways (acting, writing, reading, talking, listening, deciding, questioning, drawing, etc.).
4. When learning about social science, we should be able to see what we learn represented in the world around us.
5. We learn well when we can work toward and see the impact of their learning/action praxis in their world.
6. We learn best when we access and work with our community of inquirers and human resources.
7. Literacies help us to inquire more deeply into content-knowledge. Separations of literacy, content, and mathematics are artificial and temporary.
8. We learn best when we have access to multiple texts of multiple genres to give us multiple angles on the same topic.
9. Controversy and debate are natural platforms for fueling inquiry.
10. We learn best when we have multiple tools and texts at our disposal, and we have supportive structures in place that allow us to engage with these tools and texts in deep and productive ways.
11. We learn best when we connect our classroom work to our lives at home and in our communities.
12. When reading and writing, it is important to take into account author's purpose and audience in ways that can support your making meaning in very aware ways.
13. By taking on real situations in our world, understanding them and responding to them, we learn first-hand, how/why/when/where to engage with our world as inquirers and activists.
14. We learn best when we have big ideas within which to ground our learning. These big ideas also help provide fertile ground for connections between topics that appear to be isolated within separate disciplines. Within these big ideas, literature becomes an anchor as well.

Possible Guiding Questions for Planning

Conceptual

Diversity/democracy: What are best possible perspectives to access? Which perspectives (reader, writer, mathematician, scientist and/or social scientist) offer potential insights or strategies for this inquiry?
Causation: How might we understand key relationships?
Systems: What systems are involved and how are they related?

Balance: How might balance lead us to a better understanding of this topic?
Cycles: How might cycles help us understand?
Change: How might change help us understand?
Voice: Who is heard or privileged? Who is absent or silenced?
Power: How might power structures help us better understand this issue?

Pragmatic/Universal

Who developed it?
Why, given the context and purpose?
Where did this knowledge or information come from? Can we trust or believe it?
Has our knowledge or our understanding changed over time?

Personal Knowledge

Why does this knowledge or information matter to me?
How has what I have learned changed me?

Social Knowledge

Why does it matter in the world?

From Personal Knowledge to Social Action

So what?
Now what? How might we take action on what we have learned?
How might we show what we have learned?

Questions to Frame this Particular Inquiry

- Is climate change real?
- Is climate change man made?
- What is causing climate change?
- What is our part in changing climate change?
- Do scientists agree about global warming?
- What is causing global warming?
- What is the difference between "global warming" and "climate change?"
- What are the differing views on climate change?
- What will happen if global warming continues?
- What is being done about global warming?
- What can I do about global warming?
- How is technology trying to combat climate change?

Method(s) or Investigation(s) that will Promote Authentic Inquiry

How might students learn the skillfulness of inquiry? Given the questions posed, would observations, interviews, experiments, surveys, controlled studies or other methods best support this inquiry?

- How to use a computer as a tool for inquiry

- Investigate information on your own
- Support abductive reasoning by coming to a conclusion based on supporting evidence
- Use technology to make sense of information
- Compare and contrast
- Analyze primary source features such as photos of climate change evidence
- Students read a variety of diagrams illustrating climate change
- Students construct their own diagram to demonstrate their understanding of climate change
- Students will write an opinion piece in which they must abductively come to their own conclusion concerning their climate change beliefs

Key Demonstrations and Engagements throughout this Inquiry

What are the primary teaching and learning strategies to be employed?

- Framing questions guide inquiry into climate change and global warming
- Transact with a variety of climate change diagrams
    - o Create own diagram to demonstrate understanding of climate change and global warming
    - o Use diagrams to *speak from the heart* and verbally demonstrate understanding of climate change and global warming
- Watch Bjorn Lumborg's documentary on climate change – <u>Cool It</u>
- Watch Al Gore's movie <u>An Inconvenient Truth</u>
- Compare and contrast both movies. How does each movie claim to fix climate change?
- Create a *Statement of Beliefs* paper to synthesize students' beliefs concerning climate change based on the evidence

Envisioning a Possible Touchstone Experience

Just as touchstone texts are accessed throughout units of study in reading and writing workshop and revisited over and over again to deepen and broaden learning, touchstone experiences are foundational to units of study in the sciences and social sciences. Field studies, visits to the pond, author studies, 3rd grade summer inquiry, science experiments, teaching/learning projects, genealogy projects and expert projects are a few examples of touchstone experiences. Given the key demonstrations and engagements planned, which one might best serve as a touchstone experience?

- Students will write a "Statement of Beliefs" paper to summarize beliefs about climate change they have come to believe as a result of this inquiry.

Strategies, Skills, Content and Concepts to be Addressed Through Demonstrations, Engagements and Touchstone Experiences

What standards will be uncovered through this inquiry?

- Since this unit was precluded by our unit of study on weather, the South Carolina 4th grade standards in weather were addressed:

Weather

- o 4-4.1 Summarize the processes of the water cycle (including evaporation, condensation, precipitation, and runoff).
- o 4-4.2 Classify clouds according to their three basic types (cumulus, cirrus, and stratus) and summarize how clouds form.
- o 4-4.3 Compare daily and seasonal changes in weather conditions (including wind speed and direction, precipitation, and temperature) and patterns.
- o 4-4.4 Summarize the conditions and effects of severe weather phenomena (including thunderstorms, hurricanes, and tornadoes) and related safety concerns.
- o 4-4.5 Carry out the procedures for data collecting and measuring weather conditions (including wind speed and direction, precipitation, and temperature) by using appropriate tools and instruments.
- o 4-4.6 Predict weather from data collected through observation and measurements.

ELA Standards

- o 4-1.11 Read independently for extended periods of time for pleasure.
- o 4-2.1 Summarize evidence that supports the central idea of a given informational text.
- o 4-2.2 Analyze informational texts to draw conclusions and make inferences.
- o 4-2.3 Analyze informational texts to locate and identify facts and opinions.
- o 4-2.6 Use graphic features (including illustrations, graphs, charts, maps, diagrams, and graphic organizers) as sources of information.
- o 4-3.1 Generate the meaning of unfamiliar and multiple-meaning words by using context clues (for example, those that provide an example or a definition).
- o 4-3.2 Use base words and affixes to determine the meanings of words.
- o 4-4.3 Create multiple-paragraph compositions that include a central idea with supporting details and use appropriate transitions between paragraphs.
- o 4-6.2 Use print sources (for example, books, magazines, charts, graphs, diagrams, dictionaries, encyclopedias, atlases, thesauri, newspapers, and almanacs) and non-print sources to access information.

Strategies for Reflecting on and Documenting Learning

How might we demonstrate growth and change? What are our new questions?

- Student will use *I Think I Know…* folder to document understanding of climate change. Through the use of the folders, students will also observe how their understanding has changed over time
- Students will create diagrams of their understanding of climate change. Students will use these diagrams to verbally share their understanding. The diagrams become a place holder of their understanding

Reflexivity: Studying Ourselves and the Implementation of this Unit of Study to Grow and to Change

How did it go? What do we want to hold onto? What do we want to revise?

I like the overall structure of the unit, including some of the keystone activities. I liked how the unit was premised with our weather unit (in 4th grade), which provided a seamless segue into climate change. I liked that the unit seemed to be broken into two chunks: learning about climate change and taking our knowledge of climate change to form an opinion. I especially liked the keystone activity – having students create a statement of beliefs paper. I liked how diagrams became an important part of this unit, and how diagrams helped students make better sense of climate change (next time I would definitely have students use diagrams much sooner in the unit). I collected lots of online sources but used only a fraction of them. Now that I have done the unit, it would be best to go through sources of information and rank them in terms of importance, or at the very lease, organize them according to how I broke up the unit.

I need to do a better job of using the resources, and allow students to use those resources to better draw their own conclusions. My worry throughout the unit focused on whether students believed what they believed based on what I shared. I always strived to glean my opinions from what was presented but this unit demonstrated how difficult that was.

I also felt this unit lacked a "social justice" element to it. That was supposed to be sufficed through the USA-NPN citizen science engagement. But because of time, I felt we never addressed the "What can we do about climate change?" question that should be addressed in this unit.

Data Sources (primary and secondary) to Support this Inquiry: Envisioning Text Sets with Books, Videos and Artifacts

Climate Change Documents and Resources (need to be printed)

- http://www.epa.gov/climatechange/downloads/Climate_Basics.pdf (frequently asked questions)
- http://www.globalchange.gov/images/documents/toolkit/Glossary/Glossary_Entire_wout_Citations_6_9_09.pdf (climate change vocabulary)
- http://www.globalfever.net/Global_Fever/Climate_Change_Curriculum.html (teacher and student curriculum on climate change)
- http://www.climateclassroomkids.org/default.aspx (Climate Classroom website has games and such)
- http://www.climateclassroomkids.org/popup_slideshow.html (global warming slideshow with presenter's guide)
    - http://online.nwf.org/site/DocServer/cc_whats_up_with_global_warming_guide.pdf?docID=1782 (the presenter's guide)
- http://sitescontent.google.com/google-earth-for-educators/classroom-resources/lesson-plan-library/impact-of-climate-change (Google's resources for teachers)
- http://learning.blogs.nytimes.com/2009/12/09/climate-change-in-the-classroom/ (NY Times resources for teachers and climate change)

- http://www.pbs.org/now/classroom/globalwarming.html (PBS website for global warming)
    - http://www.pbs.org/now/classroom/global-warming-lesson-plan.pdf (PBS lesson plans for teachers on global warming - go with website)
- http://www.nws.noaa.gov/om/brochures/climate/Climatechange.pdf (brochure on "What is Climate change?")
- http://www.skepticalscience.com/docs/Debunking_Handbook.pdf (handbook
- http://climate.biol.sc.edu/~helmuthlab/Education/K12LessonPlans/LessonPlansHome.html (teacher resources and lesson plans for teachers)
- http://www.epa.gov/climatechange/emissions/wheel_card.html (EPA global warming wheel chart - calculates individual emissions)
- http://education.arm.gov/ (US Department of Energy climate site for kids - resources for kids and teachers
- http://mynasadata.larc.nasa.gov/ClimChg_lessons.html (NASA lesson plans using real life NASA data)

Climate Change Websites for Kids

- http://news.bbc.co.uk/cbbcnews/hi/specials/climate_change/default.stm (has some good basic information on global warming)
- http://climate.nasa.gov/kids/ (NASA's website on global climate change – this site has lots of great information including info on carbon, greenhouse effect, and global effects)
- http://www.climateclassroom.org/ (NWF's website for kids and climate change -– a variety of information but not a very friendly site to use. Make sure to look at the column on left to navigate information)
- http://www.c2es.org/global-warming-basics/kidspage.cfm (climate change website which offers possible answers to kids questions – addresses the following questions:
    - **Do scientists agree about global warming?**
    - **What is causing global warming?**
    - **What is the difference between "global warming" and "climate change?"**
    - **What will happen if global warming continues?**
    - **What is being done about global warming?**
    - **What can I do about global warming?**
- http://climatechangeeducation.org/ (climate change website for kids with all sorts of info such as video, research, science experiments, etc.)
- http://www.kidsnewsroom.org/climatechange/ (EPA's website for kids - this is a great website and should be used for introducing new concepts)
- http://www.epa.gov/climatechange/kids/ (another EPA kids website)
- http://hawthornheating.com/info/heating-up-the-earth-global-warming-for-kids (website containing many kids websites on climate change – good resources)

Articles for Kids

- http://www.sciencenewsforkids.org/2004/11/a-change-in-climate-2/ (good article for beginning unit of study)
- http://news.yahoo.com/classrooms-become-next-battleground-climate-change-skeptics-153203067.html (this will probably be the article I begin the unit - addresses climate change facts, skepticism, the controversy in class, and how kids need to take their knowledge of science and make their own decisions)

TED Talks

- https://www.ted.com/talks/lang/en/al_gore_on_averting_climate_crisis.html (Al Gore discusses averting climate change)
- https://www.ted.com/talks/lang/en/al_gore_s_new_thinking_on_the_climate_crisis.html (Al Gore discusses new thinking on climate change)
- https://www.ted.com/talks/lang/en/al_gore_warns_on_latest_climate_trends.html (Al Gore presents new information on climate change)
- https://www.ted.com/talks/lang/en/david_keith_s_surprising_ideas_on_climate_change.html (David Keith presents a dramatic way of dealing with climate change)
- https://www.ted.com/talks/lang/en/james_balog_time_lapse_proof_of_extreme_ice_loss.html (time lapse photography of receding ice glaciers)
- https://www.ted.com/talks/lang/en/yann_arthus_bertrand_captures_fragile_earth_in_wide_angle.html (captures fragile earth in photography)

Other Videos

- http://video.pbs.org/video/1881274265 (Katharine Hayhoe - Climate Evangelist: middle section she discusses Christianity and science)

Climate Change Websites

- http://www.globalchange.gov/
- http://climate.biol.sc.edu/~helmuthlab/index.html (Helmuth Labs climate change website)
- http://weatherclimatematter.blogspot.com/ (Jim Gandy's blog on climate change - could be good resource to discuss with kids when they put together their own blogs)
- http://www.google.com/landing/cop15/ (Google's climate change website)
- http://www.climatehotmap.org/index.html (interactive map of global warming effects - this is one of my favorites - this needs to be one of the first place students go to see a visual of global warming) – good resources and can use to see the effects of climate change
    - http://www.climatehotmap.org/global-warming-glossary/a.html (global warming vocabulary - an online glossary of global warming vocabulary)
    - could create our own using presentations

- http://www.skepticalscience.com/ (website which emphasizes science as skepticism - have people find out for themselves)
- http://www.aip.org/history/climate/timeline.htm (global change timeline)

Science Experiments

- http://sln.fi.edu/tfi/activity/earth/earth-5.html (greenhouse effect in a jar)

Various Other Articles

- http://news.yahoo.com/farmers-may-kicked-off-local-climate-change-3-205700360.html (article about how farmers may have started climate change 3500 years ago)
- http://news.yahoo.com/wheres-snow-not-lower-48-elsewhere-230700692.html (article on how there seems to be less snow in the past years)
- Methane in the Antarctic(article on how methane from the Antarctic is accelerating climate change)
- http://www.nytimes.com/2010/02/28/opinion/28gore.html (op-ed article by Al Gore on why climate change can't be ignored)
- http://www.aljazeera.com/news/africa/2011/12/20111210201555253969.html#.TuRlGPWa4IA.facebook (article on UN climate change deal)
- http://www.nytimes.com/interactive/2009/12/07/science/20091207_CLIMATE_TIMELINE.html (NY times information on science and politics of climate change)
- http://www.popsci.com/science/article/2012-03/2012-heat-wave-almost-science-fiction-mind-boggling (Popular Science article on 2012 heat wave)

Google Earth Filters

- http://news.nationalgeographic.com/news/2011/11/111128-google-earth-dams/# (shows how damming rivers could impact climate change)
- http://www.gearthblog.com/blog/archives/2008/05/climate_change_data_for_google_eart.html (Google Earth climate change filters from their blog
- http://www.google.com/landing/cop16/climatetours.html (Exploring climate change in Google Earth)
- http://sitescontent.google.com/google-earth-for-educators/classroom-resources/lesson-plan-library/impact-of-climate-change (Google's resources for teachers including Google Earth filters)
- http://nsidc.org/data/virtual_globes/ (NSIDC's Google layers to see how ice and snow have been impacted)

iTunes U Resources

- http://itunes.apple.com/us/course/climate-change/id499099250 (TED / iTunes U conferences on climate change - contain several of the same videos from the TED talks I have collected)

- http://itunes.apple.com/us/podcast/center-for-climate-energy/id437917753 (podcast for the Center for Climate and Energy Solutions)

iTunes Apps

- http://itunes.apple.com/us/app/climatecounts/id342541675?mt=8 (Climate Count - analyzes companies to see how well they are addressing climate change concerns)
- http://itunes.apple.com/us/app/climate-mobile/id388928572?mt=8 (provides climate change trends worldwild; comes from NASA and NOAA data)
- http://itunes.apple.com/us/app/climate-mobile/id388928572?mt=8 (NASA's app that visualizes recent global climate change data - my favorite)
- Climate Change Apps (list of climate change apps - haven't been through these yet)

Global Warming Skeptic / Hoax Sites

- http://www.globalwarminghoax.com/ (not anti-climate change but anti climate change caused by man)
- http://www.wnho.net/global_warming.htm (contains articles debunking global change)
- http://www.americanthinker.com/2011/07/the_global_warming_hoax_how_soon_we_forget.html (article debunking global change - lots of data)
- http://www.globalclimatescam.com/documents/FiveFacts.pdf (brochure debunking climate change)
- http://www.forbes.com/2011/01/03/climate-change-hoax-opinions-contributors-larry-bell.html (article on the climate change hoax)

Social Action

- http://www.coolschoolchallenge.org/ (schools take this challenge to see how much carbon they can reduce)
- http://www.epa.gov/epawaste/education/toolkit.htm (tools to reduce waste)

APPENDIX E

Transcript of Emily's *I Think I Know…* Folder

Table E.1

Transcript of Emily's I Think I Know…Folder

I Think I Know…	Yes! I Was Right	New Facts	I Wonder…	I Was So Wrong!
Climate change can be dangerous	Climate change is caused by things that happen in the world	Climate change is making animals migrate and is changing the environment	I wonder if the world is getting a little warm then it was in 2012	Is climate change the reason for the world to be hear
Climate change is causing __ and what they do	Is the heat caused by climate change	Climate change makes the seasons	If climate change will make another Ice Age	Climate change is almost the same thing as global warming
	Climate change is weather	Ozone is a green house gas	Climate change is an example of cause and effect	
	It can change the world	Climate change is looking through the temp. over a long time		
		Climate change can change people's lifes		
		CO_2 is a green house gas		
		Climate change can change not just land, but water too		

APPENDIX F

Transcription of Exploratory Conversation with Allana, Alexi, Mary, and Teacher

Al: Methane, ozone, and water vapor, you can actually find the actual names.

T: So make, so make sure you get those names down

Al: You can get the information about it

T: Because even though we have those definitions, we still may not be able to quite exactly understand all of those. Now, I mean, I know what vapor and carbon dioxide and methane but, nitrous oxide, I'm still, even me personally, I'm still up in the air on exactly what some of those things are.

A: Mr. Johnson, I found another reference of that. On this one, it has them printed in red.

T: But also look on your website, those are what, they are? Those words are what? [confused look on her face] They're red and they're . . . so can you click on those.

A: I noticed that cause I (inaudible) . . .

Al: Wait, I need help

T: Those are hyperlinks.

A: I clicked on the green

T: Ahh

A: . . . and like, since, and then like it gives you

Al: How did you find that?

A: [Alexi gets up and helps Allana]

T: So then, it's on the other website so on, on that website, you can click on those, those are like links to different definitions, almost like a glossary.

Al: Ah, so if you press the greenhouse effect, it will take you

A: . . . if you, if you press the thing (that is) highlighted and if the (inaudible) wasn't underlined

Al:it will give you a glossary of what the atmosphere it

T: So, so look, click on those to get those, that, information that we need.

A: So I would, I would click on carbon dioxide (inaudible)

T: Well, I mean, what is your question? What is the greenhouse effect? Can you tell me what that is? And then, what are those greenhouse gases?

A: I found, but, from what I read, I read, two different websites you sent me. They both had different

Al: the meanings

A: they both have different meanings because this one says, like, it's a rise in some temperature (inaudible) gases in the atmosphere, and then it goes into that but then this one had different ones

Al: it said the . . .

T: but, but it's all based on the same thing

Al: reads from website "the atmosphere has gases and tiny amounts that trap heat from the (inaudible)

T: So, so what we can easily say is greenhouse gases is due to certain gases in the atmosphere.

Al: Yea

T: and some of those gases do what? They . . .?

Al: they trap heat from the earth

T: They both, so they both say that, they just both say it differently.

Al: Oooohhhh [exaggerated]

A: Like um . . .

T: but they're both, but they're both talking about gases, atmosphere, and trapping in heat. And this is, and actually this is the picture that Maria even showed me and she used that picture as a description of it so read that picture right there, read that diagram

A: [reads diagram] that's the sun, the gases are like right here, that some of the heat escapes into the, [inaudible] the atmosphere is right here so then the gases go in and they trap the hear right there so it goes back to earth

T: Exactly, so you have, you're right, have the sun, the sun [turns the computer]

Al: [reads the diagram] Like it escapes, into space, it goes into space and it goes to the, all the way down to the atmosphere. Then the, then the gases into the air and trap heat from the earth so it goes back

T: [pointing to diagram with Allana] So yea, the sun, it warms, it sends its rays to warm, the sun's rays warm the earth, Ok. Some of these rays, they bounce back, so they bounce off the earth, and they go back out. Sometimes they hit the clouds, sometimes these rays hit the clouds, but some heat escapes out into space

Al: and then it goes to space and then it goes all the way to the atmosphere

T: Well, I, I get what you're saying. So some of these rays, you're right, they come down and they bounce up but some of these rays don't go out into space, they get trapped inside here – why?

Al: Because of the atmosphere is, those greenhouse gases trap them.

T: Because those gases that are let out, they cause this blanket, so some of those rays don't leave and they get trapped inside. So some heat trapped by greenhouse gases and they travel back to the earth.

AlThat's why some of the states are the most hottest because of the some of the states like they're, the greenhouse gases are hitting there and it's trapping the heat in so it gets them all the way to 100 degrees

T: but it doesn't do it just over every state, does it?

Al: no it doesn't

T: if it's, if it's a global

Al: all over the world

T: exactly, it's a global warming then it, you're right, does it all over the world.

Al: So if Australia was like 30 degree one day and the heat got trapped back in the next day it was like 100 degrees

T: Sort of
Al: you would know

A: So the greenhouse, so when the sun (sends it) rays, some of the heat escapes into space which is brought back down to earth because of the greenhouse gases such as carbon dioxide and that kind of thing. Because it releases it so, so it (goes) back down to earth?

T: So yea, so some of those, you see those little black dots on that diagram, that represents the gases that, that are in the air. And we always will have carbon dioxide and those gases, um, um, if you

Al: and some of the chemicals there, carbon dioxide and I've seen like bleach, they have carbon dioxide in that.

T: Yea, so while the heat, while the sun heats up the earth, a lot of the heat escapes back into space but because of some of those gases it forms like a blanket and so some of that heat that should be going out into space gets trapped in that blanket and goes back down to earth and continues warming it

M: Oh, I get it.

Al: Yea, so it's like

T: I'm going to show you an experiment tomorrow to show you the effect of it. But one of the ways, the best, honestly the best way that I read about it. Imagine yourself in the summer.

Al: like it's hot

T: and this is horrible, imagine yourself in the summer, and oh, goodness gracious, dad locked, left you in the car

Al: Ohh

T: and the windows are down [I meant up]. So what's going to happen inside of that?

Al: it's going to get hot

T: Is it going to be hotter inside that car or outside that car?

A, An, M: Hot, it's going to be hot inside that car.

T: Why?

Al: Because the heat is trapped inside

T: the heat is trapped inside.
M: Oh yea, because everything is closed.

T: And it can't circulate. At least outside you can have some fresh air – not in the car.

An: [sounding goofy and changing her voice]

A: I have another, I have something else. Cause like, when it was hot before, before it go, well there is two different points cause in the summer time, the car, when you get in the car, like if you are getting picked up or something, like when I go out it's really hot because it's been sitting, because it's sitting there all day and if, even, even if you have the windows closed that just traps more heat inside, it traps the heat that was already in the car, inside the car, and then like, if it's on a winter day it would be less cold because, um, it still traps the heat.

T: Yea, even if you have the window open a little bit some heat can escape but the windows already up none, none of that heat can escape.

M: Like when you touch the metal part on the seat (inaudible)

Al: it will burn your hand

T: Yea, that heat just keeps staying in there like an oven.

Al: If you touch the oven, I've burned myself.

APPENDIX G

Hannah's Statement of Beliefs Paper

I think that global warming is happening and that it is caused by humans. I think that the photo's of those huge glacir in like 40 50 years its crazy I think the photo's are great modals showing how global warming is taking place, it's not showing how humans are influsing [influencing] global warming. But I am going to get to that. How I think global warming is getting influinsed [influenced] from human's because humans burn a lot of fossil fuels and fossil fuels are bad for the enviroment. Because fossil fuels relese CO_2 and sometimes methane, and people also cut down trees and trees breath in CO_2 and breath out oxagen and we need oxagen to live and we breath out CO_2 so if we don't have enogh trees to breath in CO_2 there will be to much CO_2 in the air.

If there is to much CO_2 in the air some of the sun light won't get through you may think that's good but some sun light can get through and the sun light that gets through can't get back out so that heat stays in our atmoshere because all the heat is bouncing off the CO_2 and that's making the earth warm there are also other resons like air conditioning and driving. And that's why I think global warming is caused by humans.

APPENDIX H

Beth's Statement of Beliefs Paper

I believe that climate change is real and that it is man made. The pictures Mr. Johnson showed, really where a good piece of evidence! It showed a before and after picture with different things like glaicers melting.

Both different sides of Al Gore and Bjorn Lomberg made good points! But 97% of scientist believe that climate change is man made. Al Gore wants to cut CO_2 to save the earth. However Bjorn wants to use the money to fix climate change for diaseises [diseases] and make people more healthy to save the earth.

I think the tools are accurate and the skeptics say the are'nt [aren't] but the ones that are, are saying the earth is cooling. One of the things to do is help stop climate change is paint the roofs and roads white. I like that idea. The skeptics say that the sun is reason climate change is happening and that the data is not relieable because "scientist could be making climate change up."

I believe that it is man made because we use CO_2 a lot! This means we are burning fossil fules [fuels] which all relvolves [revolves] around …climate change!

APPENDIX I

Alex's Statement of Beliefs Paper

My idea of climet change is that its man made. It's caused by man beacause we burn coil [coal] and other thing. Why we do this?

This is because coil and gas are cheap use of energy. We use those cheap use of energy to make things like gasoline.

When they burn things like coil. It realese gases like CH_4, N_2O, and CO_2.

CO_2 is one of the maine [main] ones. Also one of the hotts. CO_2 can come out of cars and green house. CO_2 can move fast also increase fast.

Mathine [methane] is a biggest too. It comes from waste most of it comes cow farts. They purduse 3,000 pound per year per cow. Also mathine is bad for the air. It is very usfull for gardening.

I learn people like Al Gore say the we should should spin billon of dollar or climet change. When some people like Bjorn say "If were going to spend billon of dollars let spend it on more important thing"

Some important things are. Hunger, clean water, diseases, education, conflict, and many more

We have lot of evidence the climet change is happening. Like glacer melting and snow. Also that flowers, fruits, and plant have grown faster.

That concluded my elsa thanks for reading

APPENDIX J

Transcript of Alex's *I Think I Know…* Folder

Table J.1

Transcript of Alex's I Think I Know… *Folder*

I Think I Know…	**Yes! I Was Right!**	**New Facts**	**I Wonder…**	**I Was So Wrong!**
I think climate change is changing in the weather	Climate change does change weather	There are lots of gases in the air	Is climate change good or bad	
I think climate change can make different types of weather		There are different gases like CO2, methane, CH4, N2O, O3, and more	Does climate change, change food	
(unable to read)		Some gases are good, some are not good		
If it is hot, warm, or cold		Gases can effect the heat		
Or if it's dry or wet		The climate is changing so the polar ice caps are melting		
It can be different temperatures		Green houses make the air hotter		
		Burning fossil fuels releases gases		

APPENDIX K

Transcript of Conversation Between Jeena, Alexi, and Teacher

J: This is the atmosphere and in the atmosphere is CFC, CO_2, ozone, methane, HFCs, and H_2O

T: and H_2O is not really water up in the air, it's what, it's water …

A: it's water molecules

T: water vapor

A: This is, this is the sun and the sun sends its sun rays (inaudible) make it to the atmosphere and then bounce off the atmosphere and some make it through and then when it hits it here it sends off its own rays called the infrared rays and some infrared rays try to leave and they have to go back down to earth

J: and this is deforestation, which um, when people cut down the trees, it releases carbon into the air.

A: Um, this is human activity. What human activity really is, is what humans are doing to make the earth warmer

T: And what are they doing to make the earth warmer?

A: Their like, using a lot of electronics and burning fossil fuels.

T: Ok. Cause' the fossil fuels do what?

A: The fossil, the fossil fuels like coal, coal and (inaudible) and natural gas, when it burns the fossil fuels it builds up inside the earth's (inaudible)

T: But it increases what? What specifically?

A: It increases the level of CO_2

T: CO_2, CO_2, which is a greenhouse gas, right?

A: Which (inaudible) cuts down trees and releases carbon dioxide, carbon dioxide into the air.

J: And in the car, the cars burn fossil fuels which releases carbon into the air.

A: And then for the buildings, then it just explains, like for fossil fuels like carbon gas, coal, coal, and natural gas which (inaudible). In big ol' factories they burn a lot of them every day and so, like coal, the coal comes and burns it all up, so

APPENDIX L

List of Citizen Science Projects

- Community Collaborative Rain, Hail, & Snow Network (CoCoRaHS) - http://www.cocorahs.org
- Project Noah - http://www.projectnoah.org
- United States of America National Phenology Network (USA-NPN) - https://www.usanpn.org
- Ancient Lives Project - http://ancientlives.org
- Project Squirrel - http://www.projectsquirrel.org
- Notes from Nature - http://www.notesfromnature.org
- The Wild Lab Bird - http://bird.thewildlab.org

APPENDIX M

Citizen Science Schedule

Monday

● Project Noah -	Beth, Mary, Jaci
● CoCoRaHS -	Emily
● Zooniverse -	Allana, Cindy, Sadie
● USANPN -	Hannah, Alexi

Tuesday

● CoCoRaHS -	Mary
● USANPN -	Hannah, Alexi

Wednesday

● Wild Lab Bird -	Chris, Brandon, John
● CoCoRaHS -	Emily
● USANPN -	Hannah, Alexi

Thursday

● Project Noah -	Alex, Thomas
● CoCoRaHS -	Mary
● USANPN -	Hannah, Alexi

Friday

● Zooniverse -	Chris, Charles, Maria, Peter, Jeena, Marissa
● CoCoRaHS -	Emily
● USANPN -	Hannah, Alexi